FEASIBILITY STUDY
SOUTH CALVALCADE

007622

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SOUTH CALVALCADE

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LIST OF ACRONYMS USED IN THE FEASIBILITY STUDY

ACLs	ALTERNATIVE CONCENTRATION LIMITS
AIC	ACCEPTABLE CHRONIC INTAKES
AOC	ADMINISTRATIVE ORDER ON CONSENT
API	AMERICAN PETROLEUM INSTITUTE
ARARs	APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
ATSDR	AGENCY FOR TOXIC SUBSTANCE AND DISEASE CONTROL
AWQC	AMBIENT WATER QUALITY CRITERIA
BOD	BIOLOGICAL OXYGEN DEMAND
BTU	BRITISH THERMAL UNIT
CDC	CENTERS FOR DISEASE CONTROL
CERCLA	COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT
COD	CHEMICAL OXYGEN DEMAND
CWA	CLEAN WATER ACT
CY	CUBIC YARDS
DAF	DISSOLVED AIR FLOTATION
EBDS	ENGINEERED BIODEGRADATION SYSTEM^{SM}
EPA	ENVIRONMENTAL PROTECTION AGENCY
FIT	FIELD INVESTIGATION TEAM
FS	FEASIBILITY STUDY
HB&T	HOUSTON BELT AND TERMINAL
HI	HAZARD INDEX
HRT	HYDRAULIC RETENTION TIME
HSL	HAZARDOUS SUBSTANCE LIST
LF	LINEAR FOOT
MCL	MAXIMUM CONTAMINANT LEVEL
MCLG	MAXIMUM CONTAMINANT LEVEL GOAL
MEGs	MULTIMEDIA ENVIRONMENTAL GOALS
NAAQs	NATIONAL AMBIENT AIR QUALITY STANDARDS
NAPLs	NON-AQUEOUS PHASE LIQUIDS
NCP	NATIONAL OIL AND HAZARDOUS SUBSTANCES CONTINGENCY PLAN
NL&CC	NATIONAL LUMBER AND CREOSOTING COMPANY
NPDES	NATIONAL POLLUTANT DISCHARGE ELIMINATIO SYSTEM
NPL	NATIONAL PRIORITY LIST
O&M	OPERATION AND MAINTENANCE
PAH	POLYNUCLEAR AROMATIC HYDROCARBONS
PCDDs	POLYCHLORINATED DIBENZO-P-DIOIXINS
PCOCs	POTENTIAL CONTAMINANTS OF CONCERN
PEPs	POTENTIAL EXPOSURE PATHWAYS
PHEA	PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT
POTW	PUBLICALLY-OWNED TREATMENT WORKS
PRC	PLANNING RESEARCH CORPORATION
PTL	PALLETIZED TRUCK LINES
QA	QUALITY ASSURANCE
QC	QUALITY CONTROL
RAA	REMEDIAL ACTION ALTERNATIVE
RCRA	RESOURCE, CONSERVATION AND RECOVERY ACT
RI	REMEDIAL INVESTIGATION

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RMCL	RECOMMENDED MAXIMUM CONTAMINANT LEVELS
RRS	REGIONAL RAIL SYSTEM
SARA	SUPERFUND ADMENDMENTS AND REAUTHORIZATION ACT OF 1986
SBR	SEQUENCING BATCH REACTOR
SDWA	SAFE DRINKING WATER ACT
SF	SQUARE FOOT
SMCLs	SECONDARY MAXIMUM CONTAMINANT LEVELS
SWDA	SOLID WASTE DISPOSAL ACT
TDWR	TEXAS DEPARTMENT OF WATER RESOURCES
TEFs	TOXIC EQUIVALENCY FACTORS
TWC	TEXAS WATER COMMISSION
UV	ULTRA-VIOLET
VOCs	VOLATILE ORGANIC COMPOUNDS
WPC	WOOD PRESERVING CORPORATION

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EXECUTIVE SUMMARY

PURPOSE

The objective of this Feasibility Study (FS) is to identify and evaluate potentially applicable alternatives to remediate unsaturated soils in localized areas and shallow aquifer groundwater at the South Cavalcade CERCLA site.

SITE DESCRIPTION

The South Cavalcade site is located in the northern section of Houston, Texas. The site occupies approximately 66 acres forming a rectangular shaped area with the longest dimension oriented north to south. The eastern and western boundaries of the site are formed by railroad tracks owned by Houston Belt & Terminal (HB&T). The northern edge of the property is bounded by Cavalcade Street and the southern border runs along Collingsworth Street.

Within the site, the area consists of Transcon Lines in the northern end, a large undeveloped portion of land occupying the central region, and Merchants Fast Motor Lines and Palletized Truck Lines in the southern end. The three businesses are all trucking companies which use this property for loading trucks.

BACKGROUND

In 1910, the National Lumber and Creosoting Company acquired ownership of approximately 55 acres to build and operate a wood treating facility. National Lumber and Creosoting Company operated the site until 1938 when they were acquired by the Wood Preserving Corporation, a subsidiary of Koppers Company. The facilities on the site consisted of several buildings which housed wood treating processing equipment, offices, railroad tracks on the northern and southern ends, coal tar operations and storage tanks, extensive lumber storage yards and two wastewater spray ponds. Based on 1938 aerial photographs, processing operations including treating cylinders, work tanks, drip tracks, and spray ponds were conducted along the southern portions of the site while storage of treated and untreated lumber was in the northern and middle sections of the site.

In 1940, the Wood Preserving Corporation became part of Koppers Company. In 1944, Koppers Company incorporated and became Koppers Company, Inc. Records indicate that the site was operated as a wood treating and coal tar distillation facility until 1962, when the plant was dismantled and the property was sold to Merchants Fast Motor Lines, Inc.

In 1962, Merchants Fast Motor Lines sold the 55-acres tract to Mr. Gene Whitehead who also purchased an additional 12 acres in 1963. Mr. Whitehead then subdivided the property and in 1965, 1969, and 1977 sold portions of the property.

A contaminant survey was conducted in 1983 by Camp Dresser & McKee, Inc., (CDM) to evaluate the suitability of the site for use as a maintenance yard and transit station for the proposed METRO-Stage One, Regional Rail System (RRS). The contaminant survey included a preliminary evaluation of shallow soil and groundwater conditions, primarily located throughout the northern portion of the site, with limited analytical testing. Results from the study indicated the potential for localized areas of contamination.

As a result of the Cavalcade Contaminant Survey Report, the site was referred to the Texas Department of Water Resources (TDWR). On April 16, 1984, the TDWR recommended to the U. S. Environmental Protection Agency (EPA) Region VI that the South Cavalcade Site be placed on the updated National Priorities List (NPL). On March 28, 1985, Koppers Company, Inc., entered into an Administrative Order on Consent (AOC) with the U. S. Environmental Protection Agency, Region VI. On June 10, 1986, the South Cavalcade Site was included on the final NPL. The South Cavalcade Site ranks 415 out of 802 sites included on the July 1987 NPL.

In 1985, a remedial investigation/feasibility study (RI/FS) was initiated for the South Cavalcade site. The RI was completed in mid 1988. This document is the FS report which includes the Public Health and Environmental Assessment (PHEA) and the Development and Evaluation of Remedial Action Alternatives.

PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT

As part of the FS, a Public Health and Environmental Assessment (PHEA) was performed. The Final PHEA built upon the preliminary PHEA presented as Section 9.0 of the Remedial Investigation (RI) Report. The Final PHEA is comprised of 5 parts:

- o hazard identification and toxicity assessment
- o exposure assessment
- o risk characterization
- o environmental risk assessment
- o sources of uncertainty

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Hazard Identification and Toxicity Assessment. The data collected in the RI was assembled, summarized and evaluated in the Preliminary PHEA. The chemicals selected as potential contaminants of concern (PCOCs) are presented in Table ES-1. Toxicological Profiles for these PCOCs were presented in the RI Report.

Exposure Assessment. Potential exposure pathways (PEPs) from the RI report were screened in the PHEA. Those PEPs found to be complete were retained and are listed in Table ES-2.

PEPs for exposure to soils were evaluated for commercial exposures (utility workers, construction workers, on-site truckers) and potential future residents. Soil data collected during the RI and later determined to be free of laboratory problems (valid data) were used to estimate exposure to PCOCs. There were only four valid soil samples for metal PCOCs and two for organic PCOCs. The two organic samples showed no detectable organic PAHs, one of the most likely site PCOCs. Half of the detection level for PAHs was used to estimate the concentration as a conservative estimate of the true sample concentration in these samples.

PEPs for sediments were evaluated for exposures to older children playing in the drainage ditches on-site and surrounding the site.

PEPs for groundwater were evaluated for exposure points of off-site wells located in deeper aquifers. Because the site PCOCs have not migrated to these points and the

TABLE ES-1

POTENTIAL CONTAMINANTS OF CONCERN

Metals:

- Arsenic
- Chromium VI
- Copper
- Lead
- Zinc

Total PAHs

Potentially Carcinogenic PAHs:

- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Chrysene
- Dibenzo(a,h)anthracene
- Indeno(1,2,3-cd)pyrene

Light Aromatics:

- Benzene
- Ethylbenzene
- Toluene
- Total Xylenes

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TABLE ES-2
SUMMARY OF THE POTENTIAL EXPOSURE PATHWAYS AND POTENTIAL RECEPTORS IDENTIFIED FOR QUANTIFICATION AT THE KOPPERS SOUTH CAVALCADE SITE

Current or Future	Media	Potential Pathway	Potential Human Receptor
Current and Future	Surface and Surficial Soil	Inadvertent Ingestion, Dermal Contact, Dust and Volatile Inhalation	Utility Workers
Current and Future	Surface and Surficial Soil	Inadvertent Ingestion, Dermal Contact	Commercial Occupants
Future	Surface and Surficial Soil	Inadvertent Ingestion, Dermal Contact, Dust and Volatile Inhalation	Construction Workers
Future	Surface and Surficial Soil	Inadvertent Ingestion, Dermal Contact	Residential Occupants
Current and Future	Sediments	Inadvertent Ingestion, Dermal Contact	Older Children
Future	Groundwater	Ingestion	Users of Aquifer at 175 feet
Future	Groundwater	Ingestion	Users of Aquifer at 550 feet

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future migration cannot be accurately predicted due to fractures in clays and an abandoned well, the exposures were based on assuming that present PCOCs in upper aquifers will migrate without decreasing in concentration. This is a very conservative assumption and may not represent the actual concentration if migration was to continue.

Risk Characterization. The potential carcinogenic and non-carcinogenic health risks were evaluated and are reported in Tables ES-3 and ES-4. The risks for exposure to groundwater are worst case estimates; the actual risks from exposure will be much lower.

Environmental Risk Assessment. A qualitative assessment of the potential risks to wildlife from PCOCs in surficial soils, sediments and surface waters was performed. Soils in the central area of the site, which is currently open and covered with grasses, are likely to form the most attractive habitat for wildlife. Since these soils did not have detectable levels of PCOCs, no risks to wildlife should be posed by these surficial soils. Wildlife contact with stained surficial soils, which are within the fenced commercial areas, is likely to be minimal. Similarly, any organisms that use or live in the drainage ditches will also only be exposed infrequently and at low levels. Groundwater in the upper aquifer may potentially migrate off-site and discharge into the Little White Oak Bayou, although currently there is no evidence to suggest that this is occurring.

In conclusion, although the possibility of adverse effects on any sensitive wildlife that may reside on the site cannot be precluded, this is considered very unlikely. The site is not likely to have wildlife on it for long periods of time and the areas having PCOCs to which wildlife may be exposed are relatively small and not as attractive as clean areas on the site.

Sources of Uncertainty. The actual risks to a person exposed to site-related PCOCs may be higher or lower than those estimated in the PHEA. The major elements which would change the risk are the actual concentration of the site contaminant, the speed of degradation of organic PAHs, the frequency of exposure, the actual toxicity of the contaminants, and a person's particular sensitivity to a site contaminant.

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Table ES-3

SUMMARY OF POTENTIAL CARCINOGENIC RISKS

A summary of the 95% upper bound excess lifetime cancer risk for potential chronic effects is shown for each source area. The potential total risk and its breakdown by PEP is also shown.

	Utility Workers (b)	Construction Workers (b)	Commercial Occupants (b)	Older Child (sediments) (b)	Future Residential Development	Future Commercial Occupants (c)
Maximum Concentration						
Ingestion	1.93E-07	3.76E-06	2.21E-07	1.33E-06	1.23E-05	7.14E-08
Dermal Contact	2.12E-09	3.97E-07	2.37E-08	7.10E-08	7.21E-07	6.97E-09
Inhalation	4.25E-09	1.80E-07	(a)	(a)	(a)	(a)
Total Risk:	2.23E-07	4.34E-06	2.20E-07	1.40E-06	1.30E-05	7.16E-08
Minimum Concentration						
Ingestion	(a)	(a)	(a)	1.45E-07	(a)	(a)
Dermal Contact	(a)	(a)	(a)	4.66E-08	(a)	(a)
Inhalation	(a)	(a)	(a)	(a)	(a)	(a)
Total Risk:	(a)	(a)	(a)	1.57E-07	(a)	(a)

(a): Risks were not calculated for this PEP.
(b): Current and future risks are equal.
(c): This exposure scenario, and the risks associated with it, are hypothetical. Risks are based on soil concentrations that have have been adjusted for degradation.

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ES-4b

Table ES-4

SUMMARY OF POTENTIAL HAZARD INDICES

A summary of the hazard index for potential chronic effects is shown for each source area. The potential total HI and its breakdown by PEP is also shown.

	Utility Workers (b)	Construction Workers (b)	Commercial Occupants (b)	Older Child (sediments) (b)	Future Residential Development	Future Commercial Occupants (c
Maximum Concentration						
Ingestion	2.28E-05	4.45E-04	2.57E-05	4.60E-03	6.17E-03	2.71E-05
Dermal Contact	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Inhalation	1.09E-06	2.14E-05	(a)	(a)	(a)	(a)
Total HI:	2.39E-05	4.66E-04	2.57E-05	4.60E-03	6.17E-03	2.71E-05
Minimum Concentration						
Ingestion	(a)	(a)	(a)	8.66E-05	(a)	(a)
Dermal Contact	(a)	(a)	(a)	0.00E+00	(a)	(a)
Inhalation	(a)	(a)	(a)	(a)	(a)	(a)
Total HI:	(a)	(a)	(a)	8.66E-05	(a)	(a)

(a): Risks were not calculated for this PEP.
(b): Current and future HI's are equal.
(c): This exposure scenario, and the HI's associated with it, are hypothetical.

DEVELOPMENT AND EVALUATION OF REMEDIAL ALTERNATIVES

The FS process focused on the development and evaluation of remedial action alternatives that may be applicable for the South Cavalcade Site, specifically to remediate the two areas of localized soil contamination and the shallow groundwater aquifer.

For the soils, approximately 30,200 cubic yards of surface and surficial soils (0-6 ft deep) occupying about 3.0 acres within the South Cavalcade site will be remediated to prevent continued migration to groundwater and reduce the potential adverse risks to public health. These areas are located in the northern and southern parts of the site. The criteria used to quantify the soil volume to be remediated were visual notations, observations during site reconnaissance, and analytical determinations.

For the groundwater, the shallow zone ranging from 10 to 20 feet will be remediated to prevent the vertical and off-site migration of contaminants to lower usable groundwater zones. It is estimated, based on detectable PAH concentrations in the groundwater, that approximately 50 million gallons of the shallow aquifer will require remediation.

Potential remedial action technologies were identified for this site and were screened based upon site-specific screening which entailed the evaluation of each technology on the basis of applicability to the local conditions. The technologies that passed the screening are listed for the soils and groundwater media on Figures ES-1 and ES-2, respectively.

The potential applicable remedial action technologies were combined to formulate remedial action alternatives based upon soil and groundwater media: surface and surficial soils and shallow groundwater. Complete site remediation will include an alternative from both groupings. The alternatives considered for each media were subjected to a detailed screening, based upon compliance with ARARs, reduction in toxicity, mobility or volume, short and long term effectiveness, implementability, cost and overall protection of human health and the environment. Table ES-5 presents a summary of this detailed analysis.

ES-5a

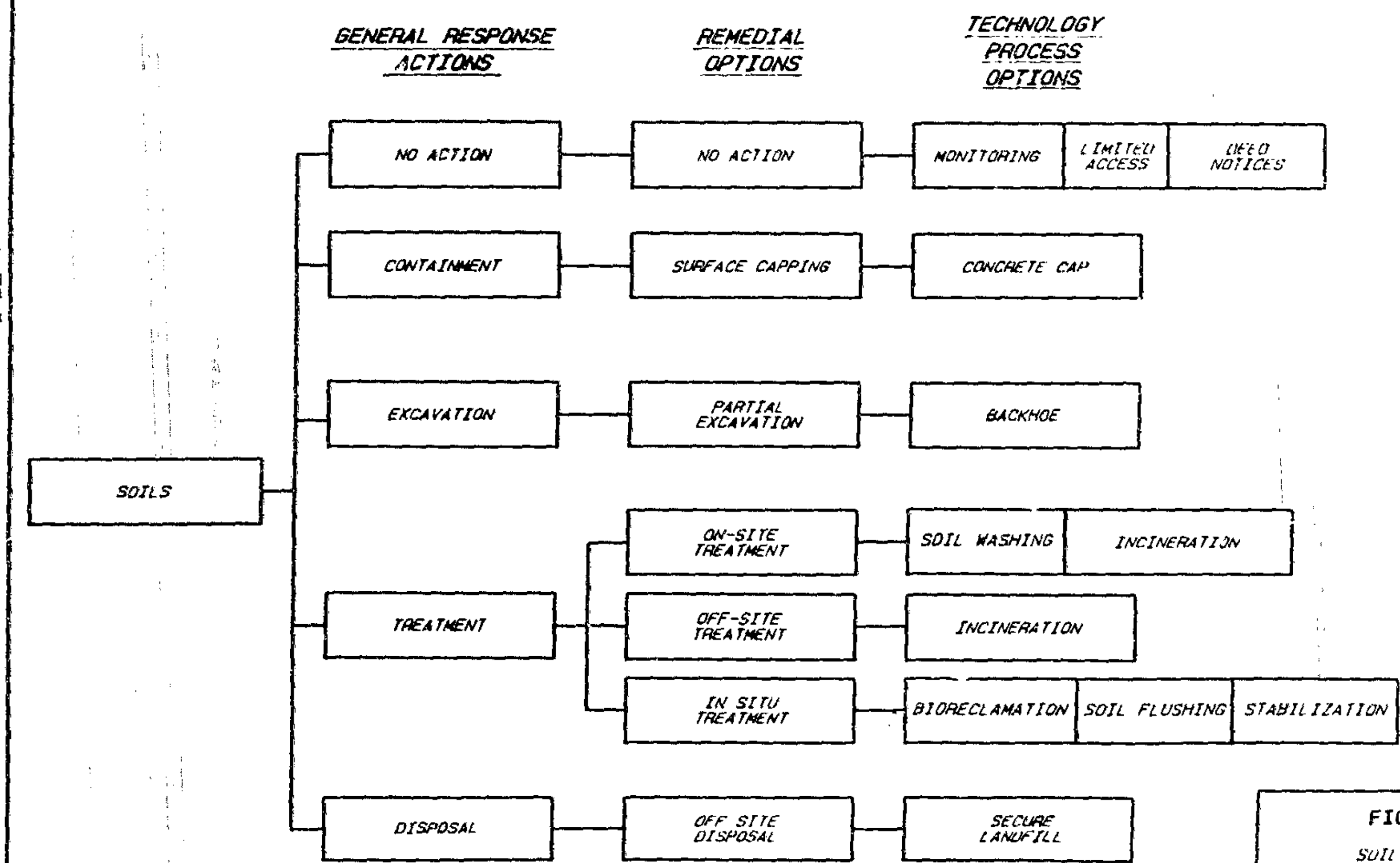

FIGURE ES-1

SOIL TECHNOLOGIES PASSING SCREENING SOUTH CAVALCADE SITE FEASIBILITY STUDY

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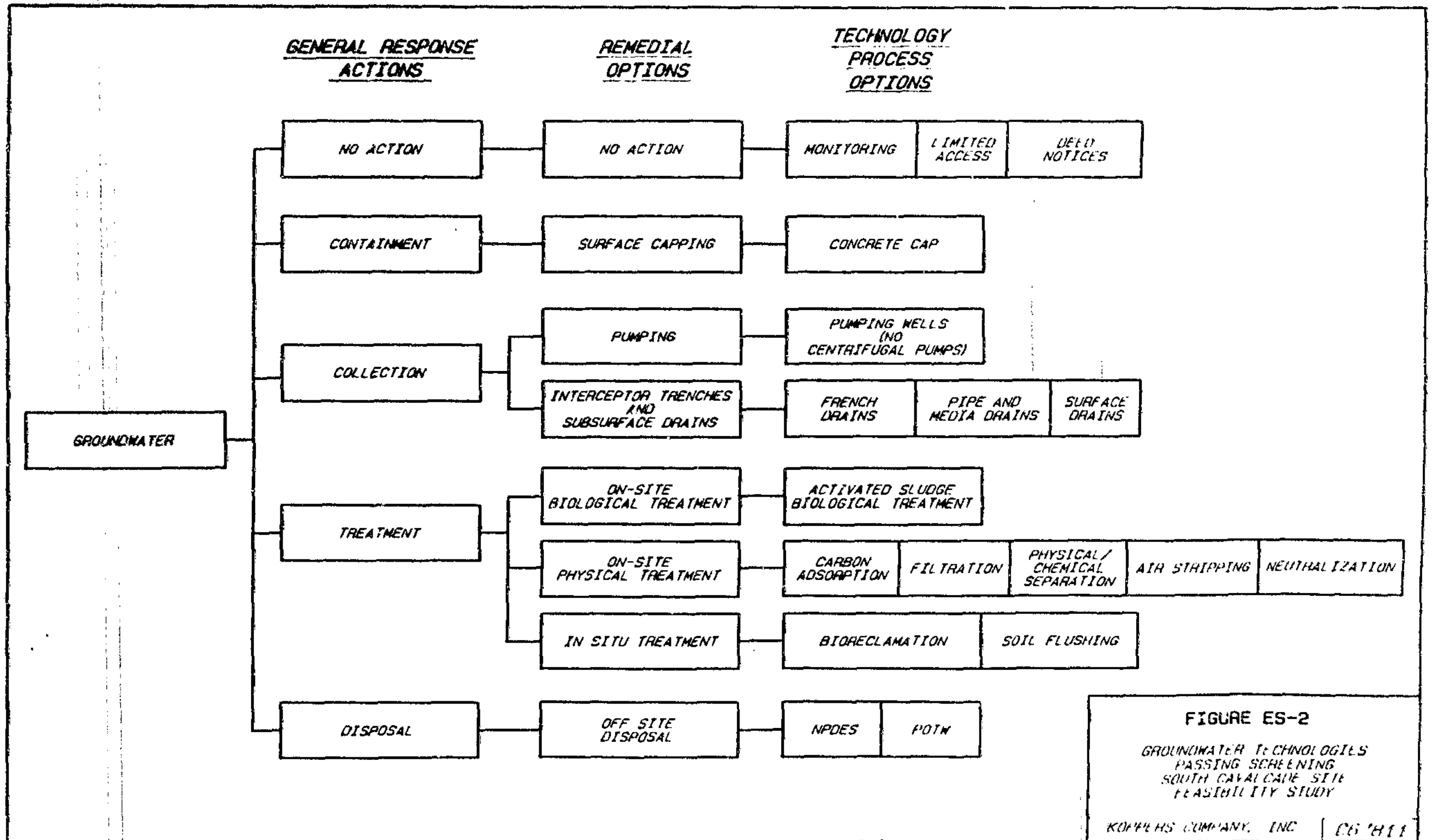

FIGURE ES-2

GROUNDWATER TECHNOLOGIES PASSING SCREENING
SOUTH CAVALCADE SITE
FEASIBILITY STUDY

KOPPERS COMPANY, INC

TABLE ES-5

SUMMARY OF DETAILED EVALUATION OF REMEDIAL ACTION ALTERNATIVES

REMEDIAL ALTERNATIVE	COMPLIANCE WITH ARARS	REDUCTION IN TOXICITY,MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	LONG-TERM EFFECTIVENESS	IMPLEMENTABILITY	PRESENT WORTH COST (1000s)	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
SOIL AND GROUNDWATER ALTERNATIVE							
Alternative 1: No Action							
	ARARs not met	Does not reduce or remove PCOCs	No increased potential risk to on-site workers	Long-term aquifer monitoring necessary PCOCs may migrate to lower aquifer	Easily monitored long-term monitoring and sign maintenance needed	$384	No reduction of potential exposure or migration pathways of PCOCs
SOIL ALTERNATIVES							
Alternative 2: In Situ Stabilization Followed by Capping							
	All ARARS met	Mobility of PCOCs is reduced No reduction in toxicity and volume	Potential for direct contact with PCOCs eliminated after cap in place Potential for worker exposure during clean up	Alternative is not permanent solution Exposure and migration reduced as long as site maintained	Easily implemented Laboratory and field studies required for fixing agent	$14,800	Human health and environment protected due to reduction in potential migration and exposure Possible future site remediation required if alternative fails

ES-5c

TABLE ES-5 (continued)

SUMMARY OF DETAILED EVALUATION OF REMEDIAL ACTION ALTERNATIVES

REMEDIAL ALTERNATIVE	COMPLIANCE WITH ARARS	REDUCTION IN TOXICITY, MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	LONG-TERM EFFECTIVENESS	IMPLEMENTABILITY	PRESENT WORTH COST (1000s)	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
Alternative 3: Excavation with Disposal at Off-Site Landfill							
	New land disposal restrictions may not be met	Complete reduction in mobility, toxicity and volume at site Toxicity and volume will not be reduced at landfill	Site remediation goals met quickly Potential for worker exposure during excavation Potential for emissions during excavation	Permanent method of remediation for site, but not for final disposal site.	Potential access problems at site Standard excavating equipment required Dome may be required over excavation	$10,000	Human health and environment protected due to elimination of potential migration and exposure pathways Potential exposure to residents in vicinity of landfill

TABLE ES-5 (continued)

SUMMARY OF DETAILED EVALUATION OF REMEDIAL ACTION ALTERNATIVES

REMEDIAL ALTERNATIVE	COMPLIANCE WITH ARARS	REDUCTION IN TOXICITY,MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	LONG-TERM EFFECTIVENESS	IMPLEMENTABILITY	PRESENT WORTH COST (1000s)	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
Alternative 4: Excavation with On-Site Soil Treatment							
On-Site Treatment Option: Soil Washing							
	All ARARs met	Toxicity, mobility and volume of PCOCs reduced Leaching of PCOCs may be problem	Quick removal of public exposure pathways Potential for worker exposure during excavation Potential for emissions during excavation	Potential for low-level leaching from treated soils	Potential access problems at site Standard excavating equipment required Dome may be required over excavation	$7,000	Human health and environment protected due to reduction of potential migration and exposure pathways
On-Site Treatment Option: Incineration							
	All ARARs met	Permanent reduction of toxicity, mobility and volume of PCOCs Metals will not be reduced	Quick reduction of PCOCs Potential for worker exposure during excavation	Permanent method of remediation	Confirmation testing and ash testing will be necessary and may delay implementation Potential access problems at site Standard excavating equipment required	$10,400	Human health and environment protected due to elimination of potential migration and exposure pathways

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TABLE ES-5 (continued)

SUMMARY OF DETAILED EVALUATION OF REMEDIAL ACTION ALTERNATIVES

REMEDIAL ALTERNATIVE	COMPLIANCE WITH ARARS	REDUCTION IN TOXICITY,MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	LONG-TERM EFFECTIVENESS	IMPLEMENTABILITY	PRESENT WORTH COST (1000s)	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
Alternative 5: In Situ Treatment							
Alternative: Bioreclamation							
	All ARARs met	Permanent reduction of toxicity, mobility and volume of PCOCs Some mobility of PCOCs could occur for material left after treatment	Potential for worker exposure during excavation Remediation of soils may be long.	Permanent method of remediation Groundwater PCOCs may be pushed off-site at Palletized Trucking Company	Relatively easy to implement Pilot or laboratory scale testing may be required before implementation	$530	Human health and environment protected due to elimination of potential exposure and migration pathways
Alternative: Soil Flushing							
	All ARARs met	Permanent reduction of toxicity, mobility and volume of PCOCs Some mobility of PCOCs could occur for material left after treatment	Potential for worker exposure during excavation Remediation of soils may be long.	Permanent method of remediation Groundwater PCOCs may be pushed off-site at Palletized Trucking Company	Relatively easy to implement Pilot or laboratory scale testing may be required before implementation	$530	Human health and environment protected due to elimination of potential exposure and migration pathways

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TABLE ES-5 (continued)

SUMMARY OF DETAILED EVALUATION OF REMEDIAL ACTION ALTERNATIVES

REMEDIAL ALTERNATIVE	COMPLIANCE WITH ARARS	REDUCTION IN TOXICITY, MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	LONG-TERM EFFECTIVENESS	IMPLEMENTABILITY	PRESENT WORTH COST (1000s)	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
Alternative 6: Excavation and Off-Site Incineration Treatment							
	All ARARs met	Permanent reduction of toxicity, mobility and volume of PCOCs	May take up to six years to reduce concentration of PCOCs Potential for worker exposure during excavation	Permanent method of remediation	Potential access problems at site Confirmation testing and ash testing will be necessary and may delay implementation Dome may be required to cover excavation	$62,000	Human health and environment protected due to elimination of potential migration exposure pathways
GROUNDWATER ALTERNATIVES							
Alternative 7: Groundwater Collection And In Situ Treatment (Bioreclamation) with Physical/Chemical Separation Followed by Disposal							
	Any new more stringent city permit restrictions may not be met	Significant reduction of toxicity, mobility and volume of PCOCs and metals Some potential for migration exists	Small potential for worker exposure to PCOCs	Permanent method of remediation	Materials and equipment readily available Acceptance of treated water by POTW may delay remediation Installation may be difficult	$6,500	Human health protected due to significant reduction in concentrations of PCOCs

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TABLE ES-5 (continued)

SUMMARY OF DETAILED EVALUATION OF REMEDIAL ACTION ALTERNATIVES

REMEDIAL ALTERNATIVE	COMPLIANCE WITH ARARS	REDUCTION IN TOXICITY, MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	LONG-TERM EFFECTIVENESS	IMPLEMENTABILITY	PRESENT WORTH COST (1000s)	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
Alternative 8: Groundwater Collection and In Situ Treatment (Soil Flushing) with On-Site Groundwater Treatment Followed by Disposal							
Groundwater Treatment Option 1: Physical/Chemical Separation Followed by Granular Media Filtration and Activated Carbon Treatment							
	All ARARs met	Significant, irreversible reduction of toxicity, mobility and volume of PCOCs	Small potential for public and worker exposure to PCOCs	Levels of PCOCs will be reduced to maximum extent possible	Materials and equipment readily available Implementation period is 8 to 12 months Need NPDES Permit	$8,300	Human health and environment protected due to significant reduction in concentrations of PCOCs
Groundwater Treatment Option 2: Physical/Chemical Separation Followed by Granular Media Filtration with Air Stripping and Activated Carbon Treatment							
	All ARARs met	Significant, irreversible reduction of toxicity, mobility and volume of PCOCs	Small potential for public and worker exposure to PCOCs	Levels of PCOCs will be reduced to maximum extent possible	Materials and equipment readily available Implementation period is 9 to 14 months Need NPDES Permit	$8,500	Human health and environment protected due to significant reduction in concentrations of PCOCs

TABLE ES-5 (continued)

SUMMARY OF DETAILED EVALUATION OF REMEDIAL ACTION ALTERNATIVES

REMEDIAL ALTERNATIVE	COMPLIANCE WITH ARARS	REDUCTION IN TOXICITY,MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	LONG-TERM EFFECTIVENESS	IMPLEMENTABILITY	PRESENT WORTH COST (1000s)	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
Groundwater Treatment Option 3: Physical/Chemical Separation Followed by Activated Sludge Biological Treatment							
	All ARARs met	Significant, irreversible reduction of toxicity, mobility and volume of PCOCs	Small potential for public and worker exposure to PCOCs	Levels of PCOCs will be reduced to maximum extent possible	Materials and equipment readily available Implementation period is 12 to 18 months Provision will be necessary for disposal of biological solids Need NPDES Permit	$8,700	Human health and environment protected due to significant reduction in concentrations of PCOCs

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1.0 INTRODUCTION

This report presents the development and evaluation of remedial action alternatives at the South Cavalcade site. A description of the Remedial Investigation/Feasibility Study regulatory framework, review of the site's history, and an overview of the approach used in conducting the Feasibility Study are addressed in this section.

1.1 Purpose

In November 1985, U.S. Environmental Protection Agency (EPA) Region VI initiated the Remedial Investigation/ Feasibility Study (RI/FS) process for the South Cavalcade site. Past wood treating operations on this site have resulted in contamination of the shallow groundwater zone underlying the site. The South Cavalcade site was recommended for addition to the Superfund National Priorities List (NPL) in 1984 and officially promulgated in June 1986.

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The Remedial Investigation conducted by Keystone Environmental Resources, Inc. for Koppers Company, Inc. was initiated to determine the nature and extent of the threat presented by the release of potentially hazardous substances, pollutants or contaminants; the extent to which the release or threat of release may pose a potential threat to public health or the welfare of the environment; the extent to which sources can be adequately identified and characterized; and to gather sufficient information to determine the required extent of remedial action. Information obtained from the RI report was conducted through the following field investigations:

- Surface Water Characterization
- Surface Sediment Characterization
- Geophysical Surveying
- Subsurface Soil Sampling
- Shallow and Deep Groundwater Investigations
- Air Quality Investigation

A total of 189 samples was collected from the South Cavalcade site. These samples included 18 surface water and sediment samples, 88 subsurface soils samples, 62 groundwater samples and 21 air samples. In addition, 20 groundwater monitoring wells were installed and field observations/measurements were performed on specific samples from the site. All sampling and analytical work were performed using Region VI EPA approved methods.

The Feasibility Study for the South Cavalcade site was prepared in order to provide for the selection of a remediation alternative that is protective of human health and the environment, attains Federal and State requirements and is cost effective. The Feasibility Study is based on data collected and compiled during the Remedial Investigation. In selecting a remediation alternative, the Feasibility Study provides an evaluation of remedial action alternatives based on the data obtained through the Remedial Investigation and subsequent field investigations.

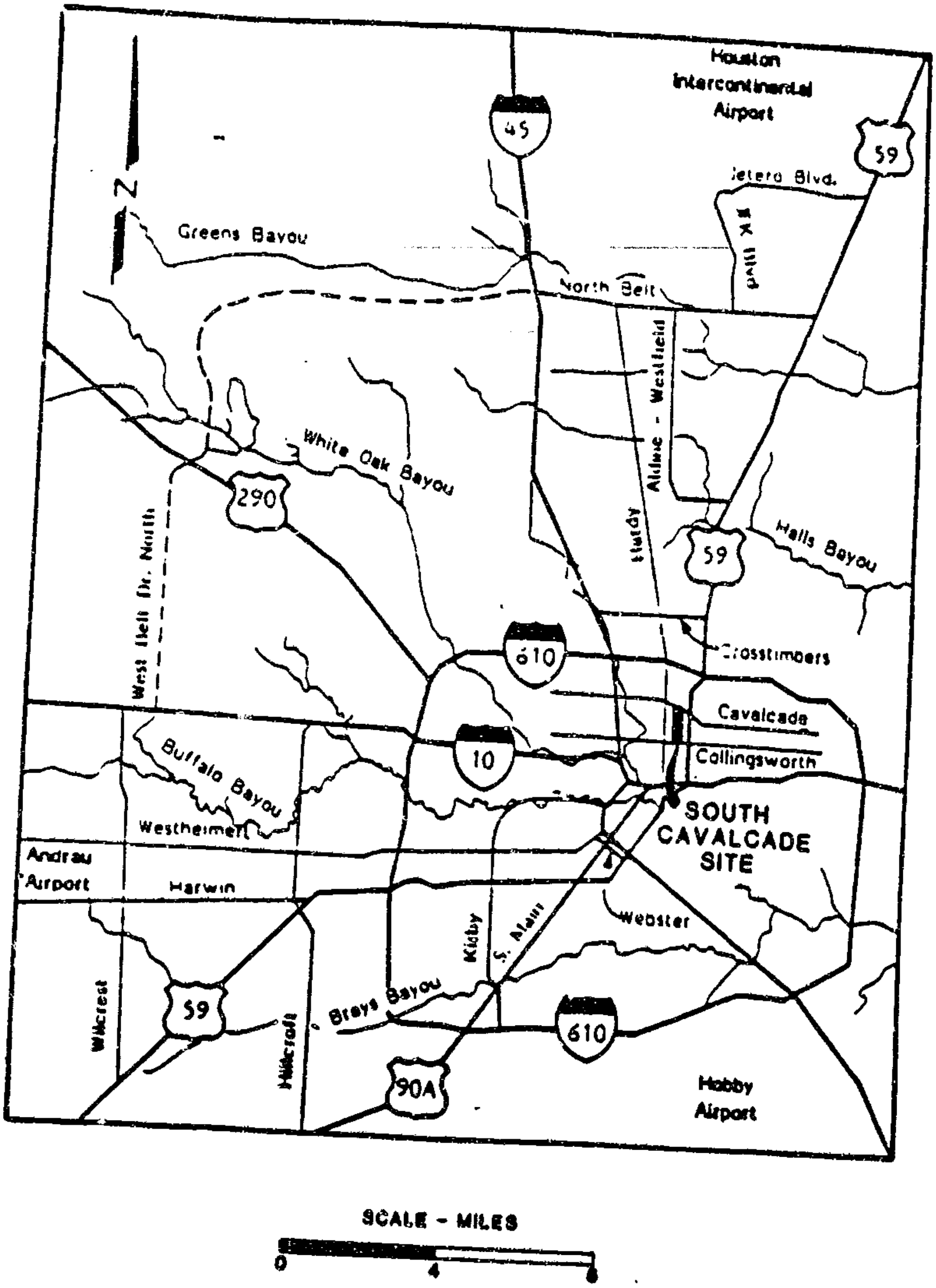
The Feasibility Study has been prepared in accordance with the provisions of the Superfund Amendments and Reauthorization Act of 1986 (SARA), the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (42 U.S.C. 9601, et seq.) and the National Contingency Plan (NCP). The U. S. EPA's document Guidance on Feasibility Studies Under CERCLA (EPA, 1985) and guidance memoranda regarding SARA were used to interpret the statutes and NCP.

1.2 Background Information

This section will discuss the previous operations which have occurred on the South Cavalcade site. A summary of property ownership and property transactions will also be discussed. Finally, site geology and aquifers will be summarized.

1.2.1 Site Description

The South Cavalcade site is located in the northern section of Houston, Texas. The site consists of approximately 66 acres forming a rectangular shaped area with the longest dimension oriented north to south. The eastern and western boundaries of the site are formed by railroad tracks owned by Houston Belt & Terminal (HB&T). The northern edge of the property is bounded by Cavalcade Street and the southern border runs along Collingsworth Street. Figure 1-1 displays the site location. The North Cavalcade site (not part of this Feasibility Study) is located north of Cavalcade



SITE VICINITY MAP

FILE NO. 85-317
FIGURE 1-1

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St. with its northern border terminating on the Route 61 beltway and is also the site of former wood preserving operations.

1.2.2 Site History

A review of the South Cavalcade site was performed to determine: (1) previous site ownership; (2) the locations of areas formerly used for wood preservation and tar distillation; and (3) locations of potential waste disposal areas. Three of the primary sources used for gathering information were: deed research, Koppers file records, and historical aerial photographs. Further discussion of these sources is given below.

Information on previous property owners was collected from the Cavalcade Contaminant Survey Report, dated July 11, 1983 and the Planning Research Corporation (PRC) South Cavalcade Title Search Report dated August 30, 1985. The National Lumber and Creosoting Company (NL&CC) purchased 55 acres of what is now known as the South Cavalcade Site in 1910. National Lumber and Creosoting carried out operations until 1938 when the site and its operations were acquired by the Wood Preserving Corporation (WPC). The WPC was a subsidiary of the Koppers Company, Inc. Wood preserving operations continued until 1962 when the property was purchased by Merchants Fast Motor Lines, Inc. (Merchants). In 1962 Merchants sold all 55 acres to Mr. Gene Whitehead. Mr. Whitehead purchased an additional 12 acres, that were adjacent to the 55 acre tract, in 1963. The additional 12 acres are located in the northwest corner of the current South Cavalcade Site. The property was sub-divided by Mr. Whitehead and various portions were sold during the next 15 years. A list of current property owners is provided in Table 1-1.

Additional deed research was conducted by McClelland Engineers, Inc. (MEI), which reported the following findings:

1. The 12 acres adjacent to the site that were purchased by Mr. Whitehead in 1963 were not previously owned or operated by Koppers. Also, there was no evidence found that any creosoting operations had taken place on this additional 12 acres.

TABLE 1-1

SUMMARY OF CURRENT PROPERTY OWNERSHIP

PROPERTY OWNER	PURCHASE DATE	ACREAGE
Meridian Transport Co. (Merchants Fast Motor Lines)	1965 1969	24.5 8.5
Baptist Foundation of Texas (Leased to Transcon Lines)	1969	22.5
Mr. Rex King	1977	10.3
Total Acres	--	65.8

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2. The South Cavalcade Site is located below Cavalcade Street and is separate from the wood preserving operations of the North Cavalcade Site (not covered in this report).

1.2.3 Site Operations

Information on plant operations and the location of plant facilities was drawn from maps which were supplied by the Sanborn Insurance Company (Sanborn). Additional site maps were also collected from Koppers. Finally, aerial photographs were obtained from various sources to help augment information from the site maps.

A 1929 insurance map shows wood treating operations being carried out in the southern section of the plant. The 1950 map from Sanborn revealed expanded wood preserving operations along with the addition of a Koppers Coal Tar Distillation Plant. Following is a list of the major facilities at the site: 007659

Wood Preserving Plant

Retort House
Spray Pond
Creosote Oil Tanks
Zinc Shed
Pond
Incinerator
Fuel Oil Tanks
Wolman Salt Tanks
Zinc Chloride Tanks
Gasoline Tank
Protexol Solution
Lime Vat

Coal Tar Distillation Plant

Pitch Pans
Spray Ponds
Still
Tar Tanks
Oil Tank

A 1938 aerial photograph shows little change between the NL&CC operation and the WPC operations except a clearing of the storage area which was the future site of the tar plant. Operations were conducted along the southern portions of the site while storage of treated and untreated lumber was in the middle section of the site.

The 1944 aerial photograph showed a similar site layout to previous photographs although there was evidence that operations were expanding northward within the site. On-going site activities occupied approximately 46 acres of the total tract. Signs of wood preserving operations were not evident within 500 ft. of Cavalcade Street.

The Tar plant and its operating facilities were identified in the southeastern portion of the site.

The 1953 aerial photograph indicated changes in the tar plant portion of the operation. Additions to the tar plant included support structures, two spray ponds, and storage tanks.

Only minor changes in the site were observed in the 1958 photograph. Some additional storage tanks were added in the tar plant area. A small ponded area appears for the first time approximately 600 feet south of Cavalcade Street. This pond corresponded to a low area in the topography and was probably the result of stormwater build-up.

Due to the change in the ownership of the site, many changes on the site were observed in the 1964 photograph. The wood preserving operations appeared to have been dismantled and removed. Also removed were the storage tanks, railroad tracks, and wood stockpiles. Portions of the tar plant had also been dismantled. The wood treating operation had been replaced by the Merchants Fast Motor Lines building and paved lot for trucks.

The 1975 aerial photograph illustrated increasing development of the South Cavalcade site. Transcon Truck Lines had established a business in the northern section of the site along Cavalcade Street. Merchants Fast Motor Lines added an extension to its facility. Only remnant features of the tar plant, including the spray ponds, were visible.

Palletized Truck Lines (PTL) was added to the list of site occupants in the 1980 aerial photograph. PTL was constructed in the area of the former tar plant. The 1984 photograph revealed that PTL had expanded its facilities. The central portion of the South Cavalcade Site has remained relatively undeveloped.

1.2.4 Site Geology

The South Cavalcade site is situated on the Quarternary Gulf Coastal Plain of Texas. This region is comprised of a series of sedimentary depositional plains, which are composed of channel fill deposits. The Koppers site is situated within the surface sediments of the Beaumont Formation, and consists of sandy to silty clays. Below this, the Lissie Formation is present and is composed of fluvial and deltaic deposits. The Pecore Fault is the closest known documented fault in the site vicinity and is located adjacent to the northern site border.

Regionally, there are three principal aquifers in the Coastal Plain. These are the Chicot, Evangeline and Jasper. The Chicot and Evangeline Aquifers are the uppermost units, and are approximately 1800 feet in thickness. Below the Evangeline Aquifer is the Burkeville Confining System, which in turn is underlain by the saline, Jasper Aquifer. Both the Chicot and Evangeline are fresh water aquifers. The uppermost water bearing unit at the Koppers site is approx. 11 feet in thickness and begins at 10-feet below grade. Small, localized permeable sand units are present at approx. 45 feet but are not considered to be an extensive water yielding unit. A thin sand (less than 10 ft) is present below this unit at approx. 90 feet. A deep aquifer zone is encountered between depths of 155 and 190 feet below ground surface.

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1.3 Nature and Extent of Problem

1.3.1 Sources and Types of Contamination

The following section discusses the preservatives used at the Former South Cavalcade wood treating facility.

FCAP

The Wolman salt tanks contained the preservative Fluor Chrome Arsenic Phenol or FCAP. The composition of FCAP is given below:

Chemical	Percent
CrO_3	37
As_2O_5	25
F	22
Dinitrophenol	16

FCAP was used as early as 1918 for wood preservation in the United States. The location of FCAP storage was in the southern section of the site. Figure 1-2 shows the approximate location of the past wood preservation operations. The preservative or "salts" were received at the plant in a dry mixture of the above concentrations. The drawback to the use of FCAP as a preservative is that it remains partially soluble in the wood which allows the preservative to be readily leached by exposure to water. The greatest potential for preservatives being spilled on the ground was leaks or drips in the process area or leaching from the stored piles of treated wood on site. Areas with the greatest potential for exposure were the preservative mixing area, drip track area, and leaks from preservative moving equipment.

<u>Creosote</u>

Creosote has been used as a wood preservative in the United States since 1875. Creosote is one of the by-products produced from the destructive distillation of coal tar. Creosote itself is made up of numerous polynuclear aromatic compounds (PAHs). The major components of the creosote oil used for pressure treating are Phenanthrene (21%), Fluorene (10%), Fluoranthene (10%), and Pyrene (8.5%). PAH compounds exhibit low levels of solubility in aqueous conditions. Due to their low solubility, PAH compounds tends to adsorb quickly to soil particles.

The potential for creosote oil and other coal tar distillates being released to site soils was greatest in the northern area, the coal tar processing area, southeastern area, the wood treating area, southwestern and/or the wood storage area. Sources of potential discharge are storage tanks, creosote transfer lines, drip tracks, treatment cylinder, spray ponds and leachate from the treated wood piles.

<u>Protexol</u>

Protexol was a trademark for a preservative used to make wood fire retardent. Protexol became a patented product in 1935 (Pat. #1,994,073 Mar. 12, 1935). The nature of Protexol used at the South Cavalcade Site consisted of a chromated $ZnCl_2$ compound. The treating solution is water soluble. However, the chromium helped to fix the Protexol to the wood. Literature on the use of Protexol as a preservative has shown that leaching due to weathering occurred at a slow, but detectable rate.

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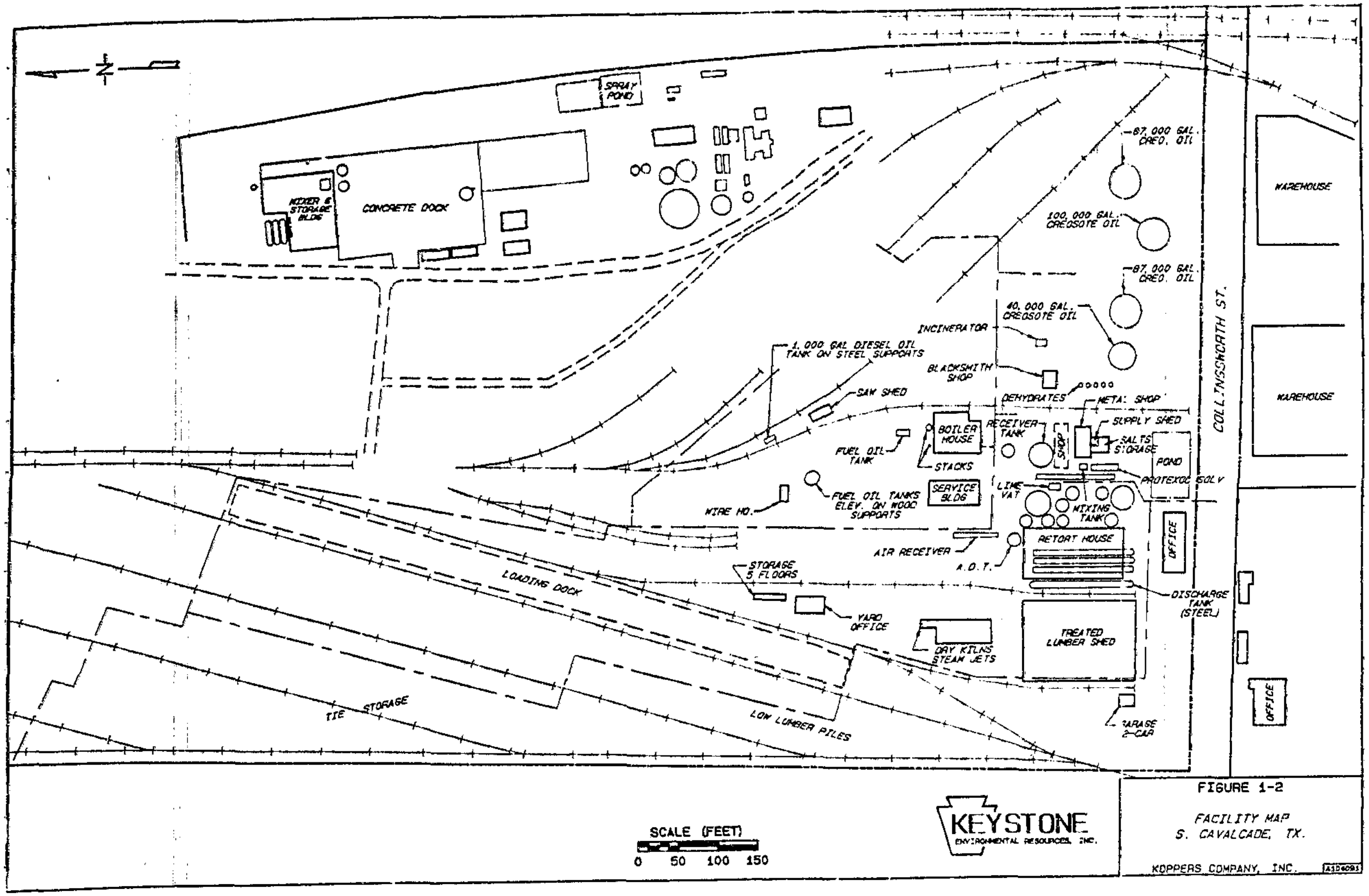

FIGURE 1-2

FACILITY MAP
S. CAVALCADE, TX.

KOPPERS COMPANY, INC.

Protexol could have been potentially released to the environment by two means: spills and leaks in the process area, and leachate from treated wood that was stored on site. The locations where Protexol had its highest potential for release to the environment are the Protexol mixing and handling areas and the drip track area located in the southern area of the site see Facility Map Figure 1-2.

1.3.2 Extent of Contamination

This section provides a summary of data collected at the South Cavalcade site. In order to present the data in a format which is most useful for the FS, the site has been divided into the following areas of interest:

- surface water and sediment,
- surface and surficial soils (0-6 ft.)
- subsurface soils (below 6 feet)
- shallow groundwater
- intermediate depth groundwater
- deep groundwater
- air

For the purposes of the FS, the South Cavalcade site has been divided into three sections: northern area, central area and southern area. The northern and central areas were used to store treated and dried wood, while the southern portion of the site was the location of a tar plant and wood treating plant.

During the Remedial Investigation, samples collected at the site were subjected to analysis for a variety of chemical parameters. For the purpose of this data summary, the categories of light aromatics (a subset of volatile organics) and polynuclear aromatic hydrocarbons (PAH- a subset of base-neutral organics) have been defined. Table 1-2 identifies the compounds in each of these categories. These categories were selected because they contain the types of chemicals typically expected at wood treating and coal tar processing facilities.

Surface Water and Sediment

A total of 18 surface water samples were collected in drainage ditches which both border the site and are found within the property limits. Surface water data indicate that no PAH compounds were detected, while volatile organics (acetone and

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TABLE 1-2

POTENTIAL CONTAMINANTS OF CONCERN

PAHs:

naphthalene
acenaphthylene
acenaphthene
fluorene
phenanthrene
anthracene
fluoranthene
pyrene
benzo(k)fluoranthene
benzo(g,h,i)perylene
chrysene
benz(a)anthracene
benzo(b)fluoranthene
benz(a)anthracene
dibenz(a,h)anthracene
indeno(1,2,3-cd)pyrene

Light Aromatics:

benzene
ethylbenzene
toluene
xylene

Metals:

arsenic
chromium
copper
lead
zinc

methylene chloride) were detected at two sample locations. However, these two compounds are considered to be an indication of laboratory cross-contamination. Several metals were detected at surface water sampling points (arsenic, zinc, lead, iron, copper, and nickel), with only arsenic exceeding the maximum contaminant level (MCL).

Five sediment samples were collected and chemically analyzed from the drainage ditches. PAH components were detected in each of the sampling locations, with concentrations ranging from 2.3 mg/Kg to 236 mg/Kg. The highest HSL PAH concentrations were detected in the southern end of the site. Volatile organic compounds (VOA) were also present in the five sampling locations, but were limited to acetone and methylene chloride. Heavy metals, consisting of arsenic, iron, lead, and zinc, were detected at most of the sediment sampling locations. Detected sediment metal concentrations at all of the on-site sample locations were similar to background conditions, and therefore may indicate no significant impact.

Surface Soils

Evaluation of soil boring data to a depth of six feet indicated the presence of three potential shallow soil source contaminant areas. These correspond to the old tar plant, the wood preserving plant, and a northern area of the site..

Analyses of the surface soils to a depth of six feet across the site indicate that the highest levels of process related constituents are located predominantly in the southern area of the property, in the vicinity of the coal tar plant and wood treating operations. The estimated areal extent of visually stained surface soils throughout the southern area of the site is approximately 1.5 acres. Small, localized areas of surface soil contamination are also present in two areas of the northern area. Cyanide and pentachlorophenol were not detected in any of the samples. Select metals (coppers, chromium, arsenic, and zinc) were also present in the surficial soils.

Groundwater

Groundwater characterization data indicates that the highest levels of constituents of interest were observed in the southern portion of the site; primarily in the shallow aquifer (less than 20 ft. below grade). Elevated levels of several constituents were also present within the next lower water bearing zone, although this zone (intermediate approximately 50 feet) was not considered to be laterally extensive due to the discontinuous nature of the sandy lenses.

The predominate compounds identified in the shallow aquifer were PAHs, which ranged in concentration from below method detection limits to observations of non-aqueous phase creosote at several wells. Shallow zone groundwater aromatic volatile organic compounds (benzene, toluene, ethylbenzene, styrene and xylene) were detected in 7 of 18 monitoring wells. The highest measured concentration of these was 2.48 mg/L in well CAV-OW10. The concentration of metals (arsenic, chromium, copper, lead, zinc) within groundwater ranged from 0.02 mg/L to 2.6 mg/L, with the highest concentration measured in well SCK-MW06, located in the southern portion of the site, near the former coal tar process area. A total of three wells had measurable concentrations of four pesticides (Beta-BHC, 4,4'-DDE, Endosulfin I, and Gamma-BHC), although no specific pesticide distribution pattern was evident.

The nature of groundwater quality within the second groundwater interval showed a similar pattern to that of the shallow groundwater zone. A comparison of PAH distribution within the two zones shows that PAH components were detected at various well nest locations, generally mimicking that of the shallow aquifer contaminant plume.

Groundwater samples from deep monitoring wells CAV-OW06 and SCK-DW02 did not indicate detectable concentrations of either semi-volatile or volatile organics above the method detection limit. High pressure liquid chromotography (HPLC) analyses of samples from the two deep zone monitoring wells for selected PAH compounds did not detect any constituents at a detection level of 1.00 ug/l.

<u>Subsurface Soils</u>

A total of 88 subsurface soil samples (below six feet) were analyzed within the various saturated intervals for HSL semi-volatile organic compounds and select inorganics. Detectable PAH constituents were present in the shallow zone, upper intermediate zone and lower intermediate zone and lower intermediate zone. No PAHs were detected in the deep zone.

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Air Quality

An air quality investigation was conducted at the site to characterize the nature and extent of potential air contaminants, if any. Field measurements made during the survey were compared to established Multimedia Environmental Goals. This Remedial Investigation has shown that the majority of compounds identified at the site were well below the MEG levels established by EPA.

Two phenolic compounds, 2,4-dinitrophenol and 2-methyl-4, 6-dinitrophenol, exhibited upwind concentrations equalling or exceeding downwind levels and thus, indicated a higher upwind background concentration. PAH compounds were not identified in any air samples during the RI.

1.4 Overview of Feasibility Study

This Feasibility Study report is organized in seven sections plus appendices. Section 1.0 includes introductory information such as a description of the FS process, site background, and summary of the nature and extent of the problem.

Section 2.0 contains the Final Public Health and Environmental Assessment of the site (Prepared by E.R.T and Keystone). Subsections of this section include potential hazards identification, toxicity assessment, exposure assessment, risk characterization, environmental assessment, and sources of uncertainties.

Section 3.0 contains the applicable or relevant and appropriate requirements (ARARs) identified for the South Cavalcade site.

Section 4.0 is entitled Screening of Remedial Action Technologies and contains the development of the remedial action objectives for the site and the identification and screening of the remedial action technologies.

Section 5.0 contains the development and detailed evaluation of remedial action alternatives. Specific items discussed in this section include the criteria used for the evaluation of the alternatives considered under SARA or NCP. In addition, each alternative is evaluated under the proposed new statutes of section 121 of the Superfund Amendments and Reauthorization Act which includes compliance with

ARARs; reduction of toxicity; mobility or volume; short and long term effectiveness; implementability; cost; community acceptance and overall protection of human health and the environment.

Section 6.0 presents an overview and summary of the detailed analysis conducted in section 5.0.

Appendices contain the specific details of the evaluation analyses and any supporting data and information referenced throughout the FS report.

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2.0 FINAL PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT

This section of the FS presents the Final Public Health and Environmental Assessment (Final PHEA) for the Koppers South Cavalcade Site. The format of this assessment follows the methodology recommended by the U.S. EPA (1986a) and is summarized below. It builds upon the work presented in Section 9.0, the Preliminary PHEA, of the Remedial Investigation (RI) Report for the Koppers South Cavalcade Site.

- Hazard Identification: Review of the compounds found in various media and choice of potential contaminants of concern (PCOCs) for detailed assessment, based on concentration, distribution, potential toxicity and consistency of detection.

- Exposure Assessment: Identification of potential exposure pathways (PEPs), estimation of potential exposure point concentrations, comparison of concentrations to applicable standards and criteria, and calculation of intakes from exposure scenarios identified in the RI report.

- Toxicity Assessment: Review of the toxicity of each PCOC (primarily from the literature supporting standards and criteria) and an estimation of the relationship of quantity of intake (dose) to risk of toxic response.

- Risk Characterization: Evaluation of the potential current and future public health and environmental risks posed by the South Cavalcade Site.

The steps of hazard identification, including selection of PCOCs, and toxicological profiles have been executed in Section 9.0 of the RI Report. The results of those steps are summarized briefly in Section 2.1, Hazard Identification and Toxicity Assessment of this report. Section 9.0 of the Remedial Investigation (RI) Report also identified the potential exposure pathways and the potential human receptors most likely to be exposed to PCOCs at the site. Section 2.2 of this report begins by summarizing these findings and then attempts to quantify, within the limits of the specific procedures, potential current and hypothetical future exposure and risk for each of the PEPs and human receptors. In order to provide a range of potential exposure and risks, maximum and minimum PCOC concentrations are usually evaluated for each media and receptor. Both maximum and minimum exposure scenarios have been evaluated for sediments at the South Cavalcade site. However,

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information on the distribution and concentration of PCOCs in surface soils throughout the site was not available. Two samples taken from surficial depths (0.5 to 6 feet) were analyzed and assumed to be representative of both surficial and surface soil throughout the site. PAHs were not detected in either sample. Because the soil data is limited, the maximum concentrations of inorganic PCOCs and one half of the highest laboratory detection limit for PAHs in the two valid samples were used to represent potential exposures to PCOCs in surface and surficial soil. Because of limited information, exposure scenarios based on mean PCOC concentrations were not developed. Had exposures and risks associated with the exposure scenario been greater than typically allowable, then more representative scenarios would have been evaluated. Section 2.3, Risk Characterization, combines the potential intakes derived in Section 2.2 with available toxicological data (reviewed in Section 9.0 of the RI report) to determine if the site poses any potential human health or environmental risks and, if it does, to estimate their potential magnitude within the limits of the specified procedures. Section 2.4 presents an Environmental Risk Assessment of the site. Section 2.5 discusses some of the sources of uncertainty in the risk assessment process.

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2.1 Hazard Identification and Toxicity Assessment

2.1.1 Database

The data used for determining potential health risks at the Koppers South Cavalcade Site were presented in Sections 5.0, 6.0, 7.0 and 8.0 of the RI Report (Keystone, 1988). These data were obtained from samples collected by Keystone Environmental Resources, Inc. and analyzed by Keystone's Analytical Division in 1987 as part of the Remedial Investigation.

2.1.2 Selection of PCOCs

The sampling rounds conducted at the Koppers South Cavalcade Site have focused primarily on constituents potentially present at the site given the past use of the property as a wood preserving plant and coal tar distillation facility. Creosote and treating salts were the principal preservatives reported to have been used at the site for the preservation of wood, in addition to the various tars and pitch resulting from the distillation of coal tar (Keystone, 1988). All wood preserving and coal tar distillation operations at the Koppers South Cavalcade facility were permanently terminated in 1962.

A list of the PCOCs is presented in Table 2-1. The basis for selecting these PCOCs is presented in detail in Section 9.0 of the R I Report. Also included in Table 2-1 are the acceptable oral and inhalation chronic intakes (AIC), and potential oral and inhalation carcinogenic potency factors. Appendix S of the RI report contains toxicological profiles for the PCOCs; therefore, the profiles have not been included in the Final PHEA. Table 2-2, referred to throughout the text, lists those polynuclear aromatic hydrocarbons (PAHs) that are potentially carcinogenic, as identified by the U.S. EPA (1986a).

2.2 Exposure Assessment

Exposure assessment includes the following four steps: 1) identification of potential exposure pathways (PEPs); 2) estimation of potential exposure point concentrations; 3) comparison of concentrations to applicable standards and criteria; and 4) calculation of expected intakes from plausible exposure scenarios. This section describes each of these steps in detail. The final step in this PHEA is a quantification of potential adverse health risks associated with current and future PCOC intakes for maximum and minimum exposure pathways that may exist at the South Cavalcade site. It is appropriate, however, to begin with a brief definition of what constitutes an exposure pathway.

An exposure pathway is defined as the means by which an individual or a population is exposed to contaminants that originate from a source. Each pathway represents a different mechanism for exposure. As described in the Superfund Public Health Evaluation Manual (U.S. EPA, 1986a), there are four elements that must be present for a potential human exposure pathway to be complete:

1) a source and mechanism of chemical release to the environment;
2) an environmental transport medium (e.g., air, groundwater);
3) an exposure point, or point of potential contact with the potentially contaminated medium; and
4) a receptor (e.g., human) route of entry at the point of contact.

Table 2-3 contains the complete pathways that are investigated in this risk assessment.

TABLE 2-1[(a)]

POTENTIAL CONTAMINANTS OF CONCERN SELECTED FOR DETAILED ASSESSMENT AT THE KOPPERS SOUTH CAVALCADE SITE

PCOCs	AIC[(b,d)] Oral	AIC[(d)] Inhalation	Potential[(e)] Oral Carcinogenic Potency	Potential[(e)] Inhalation Carcinogenic Potency
Arsenic	NA	NA	1.50	5.00E+1
Benzene	NA	NA	5.20E-2	2.60E-2
Potentially Carcinogenic PAHs[(c)]	NA	NA	1.15E+1	6.11
Total PAHs	-	-	-	-
Chromium VI	5.00E-3	NA	NA	4.10E+1
Copper	3.70E-2	1.00E-2	NA	NA
Ethylbenzene	1.00E-1		NA	NA
Lead	1.40E-3	4.30E-4	NA	NA
Toluene	3.00E-1	1.50	NA	NA
Total Xylenes	2.00E-2	4.40E-1	NA	NA
Zinc	2.10E-1	-	NA	NA

(a) The health based criteria presented in Table 2-1 are taken from an update of EPA 1986a. An "NA" indicates that EPA does not consider that criteria appropriate for evaluating the adverse human health effects potentially caused by that chemical. A "-" indicates that EPA has not developed a health criteria to use for evaluating the potential adverse health effects caused by that chemical.

(b) AIC = acceptable intake chronic.

(c) Potentially carcinogenic PAH include benzo(a)anthracene, chrysene, benzo(b)flouranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

(d) Values of AIC have units of mg/kg-day.

(e) Values of cancer potency factors have units of $(mg/kg\text{-}day)^{-1}$.

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TABLE 2-2
POTENTIALLY CARCINOGENIC PAH

Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Chrysene
Dibenzo(a,h)anthracene
Indeno(1,2,3-cd)pyrene

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TABLE 2-3
SUMMARY OF THE POTENTIAL EXPOSURE PATHWAYS AND POTENTIAL RECEPTORS IDENTIFIED FOR QUANTIFICATION AT THE KOPPERS SOUTH CAVALCADE SITE

Current or Future	Media	Potential Pathway	Potential Human Receptor
Current and Future	Surface and Surficial Soil	Inadvertent Ingestion, Dermal Contact, Dust and Volatile Inhalation	Utility Workers
Current and Future	Surface and Surficial Soil	Inadvertent Ingestion, Dermal Contact	Commercial Occupants
Future	Surface and Surficial Soil	Inadvertent Ingestion, Dermal Contact, Dust and Volatile Inhalation	Construction Workers
Future	Surface and Surficial Soil	Inadvertent Ingestion, Dermal Contact	Residential Occupants
Current and Future	Sediments	Inadvertent Ingestion, Dermal Contact	Older Children
Future	Groundwater	Ingestion	Users of Aquifer at 175 feet
Future	Groundwater	Ingestion	Users of Aquifer at 550 feet

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2.2.1 Potential Exposure Pathways

As described above, potential exposure pathways (PEPs) are the routes by which potential receptors may be exposed to contaminants in air, water, or solid media (soils, sediments or sludges). Primary direct exposure pathways include ingestion, inhalation, and dermal contact. Potentially important PEPs have been identified in Section 9.0 of the RI report. The PEPs which will be subjected to quantitative evaluation are presented in Table 2-3.

2.2.1.1 PEPs Associated with Surface and Surficial Soils

Surface soil at the site extends from the surface (0 feet) to 0.5 feet; the underlying 5.5 feet is comprised of surficial soil (0.5 to 6 feet). While no valid surface soil data have been collected from the South Cavalcade Site, two valid soil boring samples have been analyzed from the surficial layer of soil. Therefore, surficial PCOC concentrations have been used to approximate PCOC concentrations in surface soils.

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In order to present a range of potential concentrations, the maximum and minimum measured concentration of inorganic PCOCs are presented. When no PCOCs were detected, as was the case for PAHs, high and low concentrations were estimated using one half of the highest laboratory detection limit and one half of the lowest method detection limits, respectively. This procedure can lead to underestimation, if the actual PCOC concentrations are just below the detection limit or if the two samples do not represent the true maximum of PAHs in soils. Other site data, including visual observation of soil staining and aromatic hydrocarbon measurements imply that detectable levels of organic PCOCs should be present in some areas of the site. However, since soil staining is very spotty, the average concentration of PAHs could be lower than the values reported by this procedure. A summary of PCOC concentrations in surficial soil is presented in Table 2-4. While maximum and minimum concentrations are presented in Table 2-4, potential exposures are estimated only for maximum concentrations.

Utility and Construction Workers

Section 9.0 of the RI report identified three PEPs for utility and construction workers who may be exposed to PCOCs in surficial soils (0 to 6 feet) during excavation. Utility and construction workers were assumed not to dig deeper than 6 feet which is the depth of the area water table. The three PEPs are inadvertent ingestion of surficial soil; dermal contact

TABLE 2-4

Summary of maximum and minimum PCOC concentrations in suface and surficial soils at the South Cavalcade Site

PCOC	MAXIMUM CONCENTRATION	LOCATION	MINIMUM CONCENTRATION	LOCATION
TOTAL PAH	87 (mg/kg)	(a)	3.2 (mg/kg)	(b)
POT. CARC. PAH	29 (mg/kg)	(a)	1.1 (mg/kg)	(b)
ARSENIC	8.8 (mg/kg)	A10-SB01-02	1 (mg/kg)	(c)
CHROMIUM	9.5 (mg/kg)	A10-SB01-02	1 (mg/kg)	(c)
COPPER	5 (mg/kg)	A13-SB01-02	2.5* (mg/kg)	(c)
LEAD	30.4 (mg/kg)	A13-SB01-02	2.5* (mg/kg)	(c)
ZINC	3480 (mg/kg)	A13-SB01-02	2* (mg/kg)	(c)

(a): Summed value of half of the maximum laboratory detection limit.
(b): Based on the summed value of half the method detection limit.
(c): Based on 13 samples including non-detects.
(*): Denotes that half the measured analytical laboratory detection limit was used as minimum concentration.

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with surficial soil; and inhalation of PCOCs which have volatilized or dust particles to which PCOCs have adhered as a result of excavation activities. However, the volatilized PCOCs may not be of concern. Appendix 2-A evaluates the contribution to inhalation risk of volatilized potentially carcinogenic PAHs. The calculations are worst case since they do not account for dispersion of volatilized compounds. The calculations show that the contribution of volatilization is small compared to the contribution of entrained soil particles as estimated in the final PHEA. Therefore, volatilization is not included as a PEP, and exposures are estimated for the remaining PEPs.

Commercial Occupants

Two potential current and future PEPs associated with exposures to soil have been identified for on-site workers who are commercial occupants of Transcom Lines, Merchant Transport Company, and Palletized Trucking: inadvertent ingestion of soil and dermal contact with potentially contaminated soils. PCOC concentrations in surficial soils are evaluated for this PEP. Exposures for the future commercial occupant scenario are estimated using the same frequency of exposure assumptions as were used for the current scenario; however, degradation of organic PCOCs was accounted for in the future scenario. After review of the relevant literature, a half life of 3.8 years was derived. (See Appendix 2-B for a more complete discussion of the derivation of the half life.)

Hypothetical Future South Cavalcade Residents

Two potential future PEPs involving soils have been identified for the hypothetical development of the South Cavalcade Site: inadvertent ingestion of soil and dermal contact with potentially contaminated soils. Potential future intakes have been calculated for children and adults. The potential hypothetical future residential scenario is based on the maximum inorganic PCOC concentrations and on one half of the highest analytical laboratory detection limit in the valid surficial soil samples. As with future commercial occupants, degradation of organic PCOCs is accounted for in the hypothetical future residential scenario. (See Appendix 2-B for a more complete discussion of the derivation of the half lives used.)

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2.2.1.2 PEPs Associated with Sediments

Section 9.0 of the RI report identified dermal contact and inadvertent ingestion as the two PEPs through which receptors could potentially be exposed to PCOCs in sediments. Potential current exposures are quantified for these two PEPs using both maximum and minimum PCOC concentrations. Potential future exposures were not quantified because they were assumed to be identical to the current exposure scenario. A summary of maximum and minimum PCOC concentrations in sediments used in the risk assessment is shown in Table 2-5.

On-Site Trespassers

For this group of receptors, two current PEPs have been identified at the South Cavalcade Site: dermal contact with potentially contaminated sediments; and inadvertent ingestion of potentially contaminated sediments. Two potential current intake scenarios - one based on maximum PCOC concentrations, the other based on minimum PCOC concentrations - have been evaluated for older children (ages 7 to 18) trespassing on the property. Younger children do not have access to the site.

2.2.1.3 PEPs Associated with Groundwater

Section 9.0 of the RI Report identified PEPs associated with ingestion of groundwater containing PCOCs. Two groundwater PEPs were for users of the aquifer at 175 to 205 feet and another PEP was for users of the aquifer at 550 feet. The aquifers shallower than 175 feet have not been historically used for water supplies according to reported water well logs. The upper aquifers may not have been used due to poor yields in these aquifers. Therefore, their hypothetical development was not evaluated.

Two PEPs associated with the aquifer at the 175 to 205 foot interval are evaluated. The first PEP (Situation 1 in Figure 2-1) involves the potential migration of PCOCs with vertical groundwater flow to the aquifer at 175 feet and subsequent transport of the PCOCs to a hypothetical future well extracting drinking water. The second PEP (Situation 2 in Figure 2-1) involves potential migration of PCOCs with horizontal groundwater flow to a hypothetical future well which is cracked and allows PCOCs to seep inside and mix with the extracted drinking water. The PEP associated with the aquifer at 550 feet (Situation 3 in Figure 2-1) involves potential migration of PCOCs with horizontal groundwater flow to an on-site

TABLE 2-5

Summary of maximum and minimum PCOC concentrations in sediment at the South Cavalcade Site

PCOC	MAXIMUM CONCENTRATION	LOCATION	MINIMUM CONCENTRATION	LOCATION
TOTAL PAH	10.2 (mg/kg)	SD11-01	2.8 (mg/kg)*	MANY
POT. CARC. PAH	5.825 (mg/kg)	SD11-01	0.990* (mg/kg)	MANY
ARSENIC	34 (mg/kg)	SD03-01	2.5** (mg/kg)	MANY
CHROMIUM	72 (mg/kg)	SD03-01	2.5** (mg/kg)	MANY
COPPER	89 (mg/kg)	SD11-01	2.5** (mg/kg)	MANY
LEAD	540 (mg/kg)	SD05-01	10 (mg/kg)	SD01-02
ZINC	1200 (mg/kg)	SD05-01	58 (mg/kg)	SD01-02

* = Denotes summed value of half of the maximum measured detection limit

**= Denotes that half the analytical lab detection limit was used as minimum concentration.

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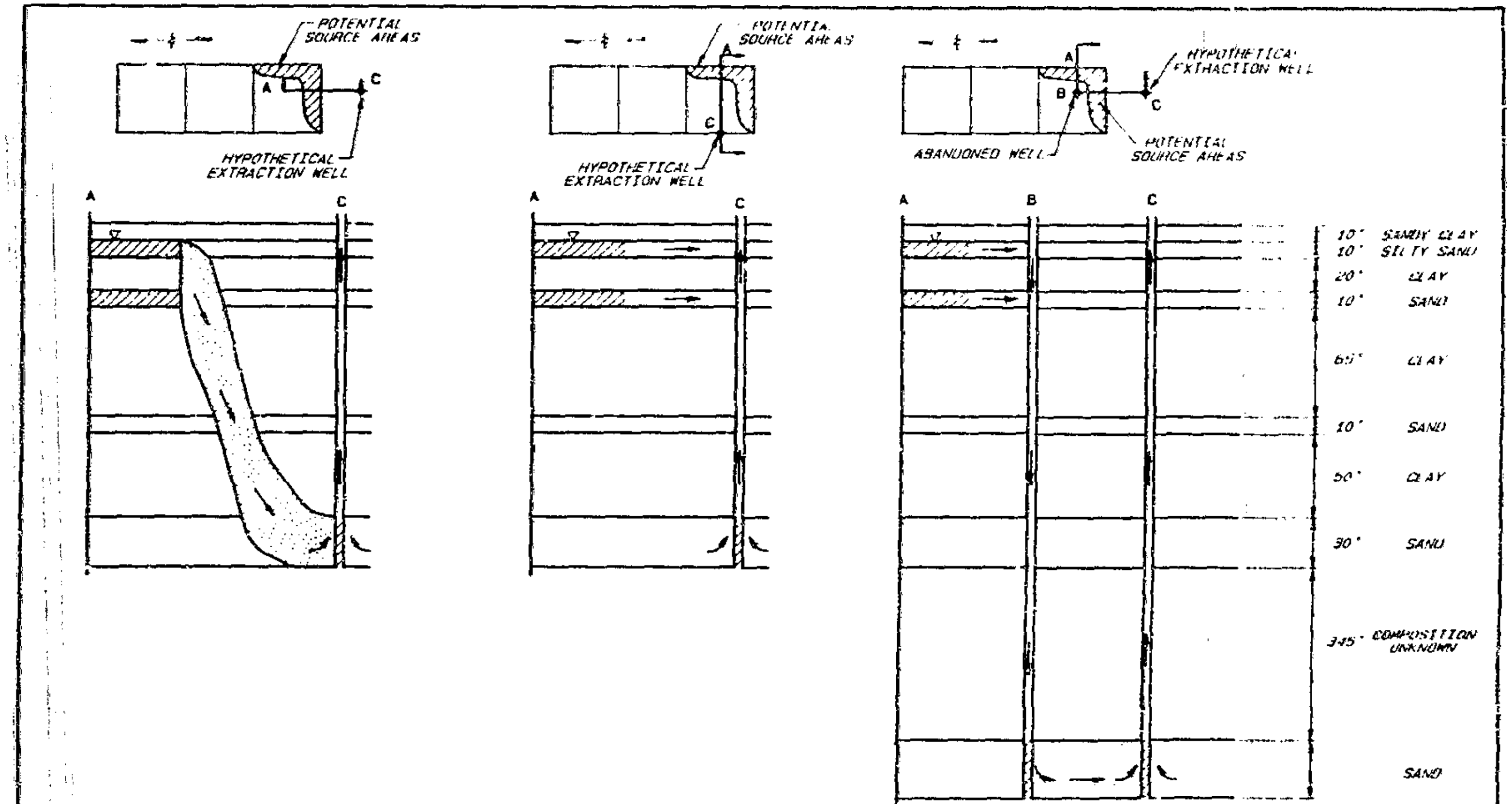

SITUATION 1:

POTENTIAL MIGRATION OF PCOCs WITH VERTICAL GROUNDWATER FLOW TO AQUIFER AT 175 FEET.

SITUATION 2:

POTENTIAL MIGRATION OF PCOCs WITH HORIZONTAL GROUNDWATER FLOW TO LEAKING EXTRACTION WELL.

SITUATION 3:

POTENTIAL MIGRATION OF PCOCs WITH HORIZONTAL GROUNDWATER FLOW THROUGH LEAKING ABANDONED WELL TO AQUIFER AT 550 FEET.

KEYSTONE ENVIRONMENTAL RESOURCES, INC

FIGURE 2-1

GROUNDWATER PEPs

KOPPERS COMPANY, INC 851244?

abandoned well, leakage of PCOCs through the well--which is assumed to be cracked and rusting--to the aquifer at 550 feet, and subsequent transport of PCOCs to a hypothetical future well which is extracting drinking water.

Situation 1: Potential Migration of PCOCs with Vertical Groundwater Flow to Aquifer at 175 Feet

As shown schematically in Figure 2-1, PCOCs can potentially migrate vertically with groundwater flow to the aquifer at the 175 to 205 foot interval. If PCOCs reach the aquifer at 175 feet, these chemicals can potentially migrate horizontally with groundwater flow in this aquifer to a hypothetical drinking water well. The hypothetical extraction well in Figure 2-1 is located south of the site because groundwater in the aquifer at 175 feet flows from north to south. The potential for PCOCs to migrate vertically through the slickenslide clays has been demonstrated by the presence of PCOCs in the sand layer at the 40 to 50 foot interval which underlies a 20 foot layer of clay. However, since no PCOCs have been detected in the 175 to 205 foot layer, the vertical migration of PCOCs has, to date, apparently been attenuated. The existence of two clay layers, one 65 feet thick and the other 50 feet thick, between the sand layer at 40 feet and the aquifer at 175 feet is probably responsible for this attenuation. While these two clay layers will probably impede future vertical migration of PCOCs to the aquifer at 175 feet for the foreseeable future, the potential for such migration exists. However, because there is no information on the permeability of the clay layers at the 50 to 115 foot and 125 to 175 foot intervals, especially quantification migration through slickenslides, accurate evaluation of this migration potential is not possible.

Situation 2: Potential Migration of PCOCs with Horizontal Groundwater Flow to Leaking Extraction Well

As shown schematically in Figure 2-1, PCOCs can potentially migrate with horizontal groundwater flow to a hypothetical future well which is extracting drinking water. If this well is cracked, then PCOCs could potentially seep into the well and mix with the drinking water. The hypothetical extraction well for this situation is shown on the western border of the site because shallow groundwater flows in an east to west direction. While the potential for this migration exists, accurate evaluation of this migration pathway is not possible due to the uncertain dilution of the site PCOCs in this hypothetical well. Therefore, it was assumed, for the purposes of estimating a worst case exposure, that the hypothetical off-site well may

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contain aqueous phase PCOCs at a level equal to that of the concentrations in the 10 foot sand. This is very conservative because adsorption to soils will likely attenuate these concentrations.

Situation 3: Potential Migration of PCOCs with Horizontal Groundwater Flow through Leaking Abandoned Well to Aquifer at 550 Feet

As shown schematically in Figure 2-1, PCOCs can potentially migrate with horizontal groundwater flow to an abandoned well. If this well is cracked or rusted, then PCOCs could potentially seep into the well and drain to the bottom of the well which is believed to be screened in the 550 foot aquifer. If PCOCs reach this aquifer, these chemicals can potentially migrate horizontally with groundwater flow in this aquifer to a hypothetical drinking water well. The hypothetical extraction well in Figure 2-1 is located south of the site because groundwater in the aquifer at 550 feet flows from north to south. While the potential for this migration exists, accurate evaluation of this migration pathway is not possible because there is no model yet which can quantify the migration of non-aqueous phase liquids (NAPLs) such as creosote. Therefore, it was assumed, for the purposes of estimating a worst case exposure, that the hypothetical off-site well may contain aqueous phase PCOCs at a level equal to that of the concentrations in the 50 foot sand. This is very conservative because adsorption to soils will likely attenuate these concentrations.

2.2.2 Estimation of PCOC Intakes

The summary of PEPs presented above and in Table 2-3 indicates that people may currently be exposed to PCOCs through the following PEPs at the Koppers South Cavalcade Site:

- o inadvertent ingestion of soil and sediments
- o dermal contact with soil and sediments
- o inhalation of PCOCs on entrained dust

Table 2-3 also identifies inhalation of volatilized PAHs as a potential PEP for utility and construction workers. However volatilization may not be of concern. Appendix 2-A evaluates the contribution of inhalation risk of volatilized potentially carcinogenic PAHs to construction workers and demonstrates that potential risks do not contribute significantly to total risk in comparison to other PEPs. Consequently, potential exposures via volatilization were not included in the intake calculations presented in Section 2.2.3.

Future PEPs include the above, as well as hypothetical ingestion of groundwater containing PCOCs. Table 2-6 lists the assumptions used in the different exposure scenarios. This section presents a detailed discussion of the PEPs, including a description of the assumptions used to estimate PCOC intakes for the groups of potential receptors that have been identified as being potentially exposed to PCOCs in soil, sediments, adsorbed to resuspended dust particulates, and in groundwater. Those potential receptors are: adult occupants working at a current or future commercial establishment; utility workers working on the current or future site; construction workers working on the site in the future; older children (ages 7 to 18) trespassing on the current site; and, younger children (ages 2 to 6), older children (ages 7 to 18), and adults living on the future hypothetically developed site.

Degradation of organic PCOCs has been accounted for in the future hypothetical surficial soil scenarios for future residents and commercial occupants. Degradation of organic PCOCs has not been accounted for in scenarios that include exposure to sediments or groundwater or exposure to buried soils.

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Potential Inadvertent Ingestion of Soil or Sediments

Children may inadvertently ingest soil while they play out of doors and adults may inadvertently ingest soil while they perform yard work or engage in other outdoor activities. Inadvertent soil ingestion exposure is estimated by combining the concentration of the PCOC in soil, the rate of potential soil ingestion, the weight of the person potentially ingesting the soil, and how often the person may potentially ingest soil.

Thus the calculation of soil ingestion is:

Ingestion (mg PCOC/kg/day) =

PCOC concentration (mg/kg soil) X ingestion rate (mg soil/person/day) X fraction of days on site in a year (day/day) X fraction of years on site in a lifetime (year/year) X unit adjustment factor (kg soil/10^6 mg soil) / body weight (kg/person).

TABLE 2-6

A SUMMARY OF POTENTIAL EXPOSURE ASSUMPTIONS

Parameter	Surface/Surficial Soil Current	Future	Ground Water Future	Sediments Current/Future	References
BODY WEIGHT (kg)					
Younger Child	--	17	--	--	(a)
Older Child	--	50	--	50	(b)
Adult	--	70	70	--	(a)
Utility/Construction Worker	70	70	--	--	(a)
Commercial Occupant	70	70	--	--	(a)
DAYS EXPOSED (day/day)					
Younger Child	--	180/365	--	--	
Older Child	--	52/365	--	12/365	
Adult	--	26/365	365/365	--	
Construction Worker	195/365	195/365	--	--	
Utility Worker	10/365	10/365	--	--	
Commercial Occupant	20/365	20/365	--	--	
YEARS EXPOSED (yr/yr)					
Younger Child	--	5/70	--	--	
Older Child	--	12/70	--	12/70	
Adult	--	53/70	70/70	--	
Construction Worker	1/70	1/70	--	--	
Utility Worker	1/70	1/70	--	--	
Commercial Occupant	20/70	20/70	--	--	
SOIL INGESTION RATE (mg/day)	100	100	--	100	(c)
INHALATION RATE (m^3/hour)	2	2	--	--	
WATER CONSUMPTION Rate (l/day)	--	--	2	-	(a)

TABLE 2-6 (continued)

A SUMMARY OF POTENTIAL EXPOSURE ASSUMPTIONS

Parameter	Surface/Surficial Soil Current	Surface/Surficial Soil Future	Ground Water Future	Sediments Current/Future	References
SKIN CONTACTING SOIL (cm^2/day)					
Child	--	2070			(b)
Older Child	--	1880	--	1880	(b)
Adult	--	1120	--	--	(b)
Construction Worker	2230	2230	--	--	(b)
Utility/	2230	2230	--	--	(b)
Commercial Occupant	2230	2230	--	--	
Soil on Skin (mg/cm^2)	0.5	0.5	--	0.5	(d)
Skin Absorption Adjustment Factor					
Organics	0.01	0.01	--	0.01	(e)(k)
Inorganics	0	0	--	0	(f,g,h, i,j)
Particulate Matter in air (mg/m^3)	0.3	0.3	--	--	

(a) EPA (1986a).
(b) Anderson et al. (1985).
(c) Clausing et al. (1987).
(d) Lepow et al. (1975).
(e) Poiger and Schlatter (1980).
(f) EPA (1981).
(g) EPA (1984d).
(h) EPA (1984e).
(i) EPA (1984f).
(j) EPA (1986c).
(k) Feldman and Maibach (1970, 1974)

Citation of any study does not constitute agreement with, nor acceptance of, the computations reported in the studies.

Potential Dermal Contact With Soil or Sediments

When children and adults are outside and contact soil, they not only may inadvertently ingest soil but they may also absorb some of the PCOCs through their skin. Dermal exposure to PCOCs in soil is estimated by combining the concentration of the PCOC in soil, the amount of skin potentially exposed to soil, the amount of soil on skin, the weight of the person potentially contacting the soil, a factor to account for reduced absorption of PCOCs through skin, and how often a person contacts soil.

The calculation of dermal exposure to PCOCs in soil is:

Dermal intake (mg PCOC/kg/day) =

PCOC concentration (mg/kg soil) X exposed skin (cm2/person/day) X soil on skin (mg soil/cm2) X fraction of days on site in a year (day/day) X fraction of years on site in a lifetime (year/year) X skin absorption adjustment factor (unitless) X unit adjustment factor (kg soil/10^6 mg soil) / body weight (kg/person).

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Potential Inhalation of Airborne Particulates

The earth-moving equipment utility and construction workers use to excavate soils may generate dust containing PCOCs. The amount of PCOCs inhaled is estimated by combining the concentration of PCOCs in the soil, the concentration of respirable particulates of soil origin in the air, the amount of air breathed, the weight of a worker, and how long a worker is exposed to the particulates. As noted earlier, volatilization of organic PCOCs may also occur but is estimated to be insignificant in comparison to exposures through other routes (Appendix 2-A).

The calculation of inhalation exposure from PCOCs on airborne particulates is:

Inhalation intake (mg PCOC/kg/day) =

PCOC soil concentration (mg PCOC/kg soil) X soil in air (mg soil/m3 air) X amount of air breathed (m3 air/day) X fraction of days on site in a year (day/day) X fraction of years on site in a lifetime (year/year) X unit correction factor (kg soil/10^6 mg soil) / body weight (kg/person).

Potential Hypothetical Ingestion of Groundwater

At some time in the future, PCOCs may reach a well used to supply potable water for domestic and commercial use. Ingestion exposure to PCOCs in groundwater is estimated by combining the concentration of PCOCs in groundwater, the weight of a person, and how much groundwater they are assumed to ingest.

The calculation of hypothetical ingestion exposure to PCOCs in groundwater is:

Hypothetical Ingestion intake (mg PCOC/kg/day) =
PCOC groundwater concentration (mg PCOC/L water) X water consumed (L water/person/day) / body weight (kg/person).

2.2.3 Potential Exposure Scenarios for Surface and Surficial Soil

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As described earlier in the RI, the South Cavalcade site is divided into three distinct areas: the southern, northern and central areas. The following description is based on observations made by ERT on a recent visit to the South Cavalcade site.

At present, a portion of the perimeter of the southern area is surrounded with a six-foot high chain-link fence, topped with three rows of barbed wire intertwined with coiled razor wire. Each gate leading to Merchants Transport Company is electrically alarmed. The northern area is also contained by an eight-foot high chain-link fence, topped with three rows of barbed wire. In addition, access is limited because there is a night security guard on duty at the front gate, located near Cavalcade Street. The central area, presently unoccupied, is heavily vegetated with grasses, bushes, wildflowers, and trees and contains no visual evidence of soil contamination.

The Houston Belt and Terminal Railroad tracks border the eastern and western sides of the South Cavalcade Site between Collingsworth and Cavalcade Roads. During the Site visit two separate trains and a truck spraying herbicides passed through the area within a three-hour period.

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2.2.3.1 Potential Current Intakes

Utility Workers

One group of potential receptors who may contact surface and surficial soils at the South Cavalcade Site are utility workers. Utility workers may potentially be exposed to PCOCs via inadvertent ingestion of soil, dermal contact with soil, and inhalation of particulates containing PCOCs. The formulas used to estimate exposures via these PEPs were described previously in Section 2.2.2. Assumptions used in the estimation of exposure are presented in Table 2-6.

Potential Inadvertent Ingestion of PCOCs in Soil. While on-site, workers were also assumed to inadvertently ingest 100 milligrams of surficial soil per day. The discussion on ingestion of soil described in section 2.2.3.2 presents the data supporting the use of 100 mg/day.

Potential Dermal Exposure to PCOCs in Soil. Utility workers were assumed to be on-site for a total of ten days, eight hours per day. This was judged to be a sufficient time period to complete a major repair. Workers were assumed to have 2230 square centimeters of skin come into contact with soil. This is equal to the entire surface area of both their hands and one half of the entire surface area of both of their arms. Other dermal exposure assumptions were identical to those used for adults contacting soil in hypothetical future exposure scenarios, as fully described in the next section (Section 2.2.3.2).

Potential Inhalation of PCOCs Absorbed onto Airborne Particulates. While working around heavy earth-moving equipment, workers may potentially inhale airborne soil particulates that contain PCOCs. Estimation of inhalation exposures require that the amount of air a worker breathes and the amount of particulates in air be estimated. Typically, an adult is assumed to inhale 20 cubic meters of air per day (U.S. EPA, 1986a). This is equal to about 1 cubic meter per hour and is representative of an inhalation rate for someone who is not performing strenuous exercise. The rate of inhalation increases with an increase in physical activity. Workers were assumed to be physically active and thus potentially be breathing at twice the standard rate. The risk assessment assumes workers breathe at the rate of 2 m^3 an hour, or a total of 16 m^3 per eight hour shift while working on site. Air at the worksite was assumed to contain 300 micrograms of particulate matter per cubic meter. This is equal to twice the National Ambient Air Quality Standard for

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particulate matter. All of the particulate matter is assumed to be respirable (less than 10 micrometers) and of on-site surficial soil origin. Thus, workers are assumed to breathe air with 300 micrograms of particulate matter per cubic meter the entire eight hours of every day they are on site. These assumptions result in an overestimate of potential worker inhalation exposures since not all particulates will be from the site and not all particulates are respirable. In addition, workers will not be active the entire 8 hours they are on site nor is it likely that the air will contain 300 micrograms of particulate for 8 hours.

Potential Total Contaminant Intake. To provide an upper bound of the range of potential utility worker exposures, the risk assessment estimates exposures for surficial soil PCOC concentrations. Potential utility worker intakes are presented in Table 2-7.

<u>Commercial Occupants</u>

Another group of potential receptors who may contact surface soils at the site are on-site workers. These workers are assumed to work at one of the three commercial transport companies located on the Koppers South Cavalcade Site: Transcom, Palletized Trucking, or Merchant Transport Company. The two PEPs of concern are inadvertent ingestion of soil and dermal contact with soil. Formulas used to estimate these exposures were previously described in Section 2.2.2. Exposure assumptions used in this scenario are presented in Table 2-6.

Commercial occupants were assumed to be outside and on-site 1 hour per day each work day, working 5 days per week, 46 weeks per year. Forty-six weeks per year accounts for a worker's annual holidays (assumed to be 12 days), average annual vacation over twenty years (assumed to be 16 days), and days a worker may be sick during the year (assumed to be 2 days). Thus a worker is assumed to be on-site 52 weeks per year less the 6 weeks he or she is away from his or her job. This is equivalent to being exposed for twenty 12 hour work days per year. The risk assessment uses a twelve hour day to account for the typically longer days worked by trucking company employees.

Potential Inadvertent Ingestion of PCOCs in Soil. While at work, a 70 kilogram worker was assumed to inadvertently ingest 100 milligrams of soil per day, identical to that for utility workers.

Table 2-7

POTENTIAL UTILITY WORKER INTAKES

Potential intake of every PCOC, broken down by PEP, is shown for a utility worker potentially exposed to PCOC concentrationd in surficial soils at South Cavalcade under current conditions. The last column shows the total potential daily lifetime intake. PCOC concentrations used to generate the potential intakes are shown in the second column. PCOCs not listed were not detected.

PCOC	PCOC Concentration (mg/kg soil)	Potential Soil Ingestion (mg/kg/day)	Potential Dermal Intake (mg/kg/day)	Potential Inhalation Intake (mg/kg/day)	Potential Total Lifetime Intake (mg/kg/day)
Total PAH	87	4.86E-08	5.42E-09	2.33E-09	5.64E-08
Pot.Carc. PAH (a)	29	1.62E-08	1.81E-09	7.78E-10	1.88E-08
Arsenic	8.8	4.92E-09	0.00E+00	2.36E-10	5.16E-09
Chromium	9.5	5.31E-09	0.00E+00	2.55E-10	5.57E-09
Copper	5	2.80E-09	0.00E+00	1.34E-10	2.93E-09
Lead	30.4	1.70E-08	0.00E+00	8.16E-10	1.78E-08
Zinc	3480	1.95E-06	0.00E+00	9.34E-08	2.04E-06

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Potential Dermal Exposure to PCOCs in Soil. Commercial occupants were also assumed to contact soil with an estimated 2230 cm^2 of exposed skin. This assumes that the entire surface area of both their hands and one half of the entire surface area of both their arms are exposed. Additional dermal exposure assumptions are described in detail in the hypothetical future intake section (Section 2.2.3.3).

Potential Total Contaminant Intake. Table 2-8 presents the estimated potential intakes for this group of receptors. The risk assessment further assumes that all of the soil that a worker contacts does not contain PCOCs. Only a small portion of the surface soil of the site is visibly stained. The total of these areas was estimated to be, at most, two acres in size. the areas also did not have any characteristics that suggest they would be visited more frequently by workers than other areas of the site. The risk assessment accounts for this by assuming that the frequency at which a worker contacts visibly contaminated surface soils is directly proportional to the fraction of the site's surface soils that are visibly contaminated. Fifteen percent of the surface soils were assumed to be visibly stained and contain PCOCs based on the stained area at one business (1.5 stained acres/10.3 total acres). Thus the total on-site soil intake was multiplied by 0.15 to account for the times a worker is assumed to contact stained soils. 007692

2.2.3.2 Potential Hypothetical Future Intakes

Construction Workers

In the event that the South Cavalcade Site is developed, construction workers may potentially be exposed to PCOCs in surficial soils. PEPs include inadvertent ingestion of soil, dermal contact with soil, and inhalation of airborne particulates containing PCOCs. The formulas used to estimate exposures via these PEPs were described in Section 2.2.2. With the exception of number of weeks on-site per year, exposure assumptions for construction workers were assumed to be identical to those used to estimate utility worker exposures. Construction workers were assumed to need a longer time period to complete their job than utility workers and, therefore, to be on the site for 39 weeks out of the year instead of 2 weeks. Because construction workers could be exposed to buried as well as surface soils, and reliable degradation values were not located for buried soils, degradation of PCOCs is not accounted for in the construction worker scenario. Table 2-9 presents the estimated potential intakes for these receptors.

Table 2-8

POTENTIAL ON-SITE WORKER (COMMERCIAL OCCUPANT) INTAKES

Potential intake of every PCOC, broken down by PEP, is shown for an on-site worker (commercial occupant) potentially exposed to PCOC concentrations in surficial soils at South Cavalcade under current conditions. The last column shows the total potential daily lifetime intake. PCOC concentrations used to generate the potential intakes are shown in the second column. PCOCs not listed were not detected.

PCOC	PCOC Concentration (mg/kg soil)	Potential Soil Ingestion (mg/kg/day)	Potential Dermal Intake (mg/kg/day)	Potential Total Lifetime Intake (mg/kg/day)
Total PAH	87	2.92E-07	3.25E-08	3.24E-07
Pot.Carc. PAH (f)	29	9.73E-08	1.08E-08	9.89E-08
Arsenic	8.8	2.95E-08	0.00E+00	2.95E-08
Chromium	9.5	3.19E-08	0.00E+00	3.19E-08
Copper	5	1.68E-08	0.00E+00	1.68E-08
Lead	30.4	1.02E-07	0.00E+00	1.02E-07
Zinc	3480	1.17E-05	0.00E+00	1.17E-05

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Utility Workers

Potential future utility worker exposures were estimated using the same frequency of exposure assumptions as were used to assess current exposures. Since the potential exposure assumptions are the same, the estimated potential future intakes for utility workers will be the same as those for current exposures presented in Table 2-9.

Commercial Occupants

Potential future commercial worker exposures were estimated using the same frequency of exposure assumptions as were used to assess current exposures. The current and future scenarios differ because the future scenario accounts for degradation of organic PCOCs over the 20 year exposure period and the current scenario does not. Table 2-10 displays the estimated potential future intakes for commercial workers.

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Residential Occupants

Two areas of the South Cavalcade Site are occupied by commercial establishments: Merchants Transport Company and Palletized Trucking are in the southern areas; Transcom occupies the northern area. The central area is currently idle and without a fence or other type of restrictive access. It is unclear what development, if any, will occur in the future. While the South Cavalcade property is bordered on the western side with residential development, it is also adjacent to other industrially developed properties. In addition, the RI report noted that the residential population has been declining since 1970, and the trend is expected to continue through the year 2000 (Keystone, 1988). Future potential exposure via contact with surface soils in the South Cavalcade Site area will be evaluated for a hypothetical scenario where the South Cavalcade area is developed as a residential subdivision.

The risk assessment assumes that a person would live in the hypothetically developed South Cavalcade Site for his or her entire 70 year lifetime and inadvertently ingests and dermally contacts contaminated soil. The exposure scenario for hypothetical future residents accounts for degradation of organic PCOCs.

Potential Ingestion of PCOCs in Soil. The U.S. EPA (1986a) has suggested that children between the ages of 2 and 6 are the individuals for whom ingestion of surface soils should be

Table 2-9

POTENTIAL CONSTRUCTION WORKER INTAKES

Potential intake of every PCOC, broken down by PEP, is shown for a construction worker potentially exposed to PCOCs in surficial soils at South Cavalcade under current conditions. The last column shows the total potential daily lifetime intake. PCOC concentrations used to generate the potential intakes are shown in the second column. PCOCs not listed were not detected.

PCOC	PCOC Concentration (mg/kg soil)	Potential Soil Ingestion (mg/kg/day)	Potential Dermal Intake (mg/kg/day)	Potential Inhalation Intake (mg/kg/day)	Potential Total Lifetime Intake (mg/kg/day)
Total PAH	87	9.49E-07	1.06E-07	4.55E-08	1.10E-06
Pot.Carc. PAH (a)	29	3.16E-07	3.53E-08	1.52E-08	3.67E-07
Arsenic	8.8	9.59E-08	0.00E+00	4.61E-09	1.01E-07
Chromium	9.5	1.04E-07	0.00E+00	4.97E-09	1.09E-07
Copper	5	5.45E-08	0.00E+00	2.62E-09	5.71E-08
Lead	30.4	3.31E-07	0.00E+00	1.59E-08	3.47E-07
Zinc	3480	3.79E-05	0.00E+00	1.82E-06	3.98E-05

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Table 2-10

POTENTIAL ON-SITE WORKER (COMMERCIAL OCCUPANT) FUTURE INTAKES

Potential intake of every PCOC, broken down by PEP, is shown for an on-site worker (commercial occupant) potentially exposed to concentrations of PCOCs in surficial soils at South Cavalcade under future conditions. The last column shows the total potential daily lifetime intake. PCOC concentrations used to generate the potential intakes are shown in the second column. PCOCs not listed were not detected.

PCOC	PCOC Concentration (mg/kg soil)	Potential Soil Ingestion (mg/kg/day)	Potential Dermal Intake (mg/kg/day)	Potential Total Lifetime Intake (mg/kg/day)
Total PAH (a)	24.3	8.15E-08	9.09E-09	8.29E-08
Pot.Carc. PAH (a)	8.1	2.72E-08	3.03E-09	2.76E-08
Arsenic	8.8	2.95E-08	0.00E+00	2.95E-08
Chromium	9.5	3.19E-08	0.00E+00	3.19E-08
Copper	5	1.68E-08	0.00E+00	1.68E-08
Lead	30.4	1.02E-07	0.00E+00	1.02E-07
Zinc	3480	1.17E-05	0.00E+00	1.17E-05

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of special concern. Estimates of the amount of soil ingested by children in the relevant age group are based on little direct data and vary widely. The minimum soil ingestion reported in the literature is 10 milligrams per day, based on presumed intake of soiled candies (Day et al, 1975), while the highest, 10 grams per day, is the upper portion of the range estimated by Kimbrough et al. (1984). The high end of predicted soil ingestion rates has been adjusted downward to 500 milligrams of soil per day (U.S. EPA, 1986a), and it has been acknowledged by the U.S. EPA that the high level of intake is probably only pertinent for children with pica (a syndrome in which children intentionally eat non-food objects).

Two studies using trace elements in fecal material have recently been published. Binder et al. (1986) estimated that 1 to 3 year old children ate soil at the rate of between 181 and 184 milligrams of soil per day to about 1834 milligrams of soil per day. They cautioned that their values were only estimates, however, since an understanding of the metabolism and absorption of trace elements is limited and other sources of trace elements in a child's diet were not accounted for. They suggested that more studies with appropriate controls are needed. A study incorporating some of the recommendations of Binder et al. (1986) was conducted by Clausing et al. (1987). Clausing et al's study estimated that nursery-school aged children ingest approximately 100 milligrams of soil per day with a standard deviation of 67 milligrams per day. The same group of researchers also measured trace element intake of a control group of children. These were hospitalized children who were unable to go outside and be exposed to soil. When the intake of trace elements is accounted for, the estimate of a child's rate of soil ingestion decreases to 55 milligrams per day. Because the estimates still have uncertainty associated with them, and in order to be protective of public health, this risk assessment assumes that children ingest 100 milligrams of soil per day, nearly twice the amount estimated by Clausing et al. (1987). The rate of soil ingestion used for the age group 0 to 5 years is the same as that recommended by Paustenbauch et al. (1987) where the available information for risk assessments of dioxin in soil was critically reviewed.

This risk assessment assumes that young children, (ages 2 through 6) will be outside and in prolonged contact with soil for 180 days of the year. This corresponds to approximately three and one half days per week. Several factors suggest that a child may be in prolonged contact with on-site soil for fewer days per year. Younger children are not likely to be outside when the weather is extremely hot and humid, as it often is in the summer in Houston. Younger children are also not likely to be outside for prolonged periods when the weather is cool, and/or wet as it can be in the winter months. Younger children are also

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likely to be taken by their parents when they go off-site to run errands. Taking all of these factors into account, the assumption that younger children will be outside and in prolonged contact with soil for 180 days per year is considered to be a reasonable assumption for the average child, noting that only direct observation can determine the exact amount of time a child is outdoors and playing in soil.

Older children and adults are assumed to engage in outdoor activity as well; however, no empirical information has been located regarding their rate of soil consumption. The risk assessment assumes that these people inadvertently ingest soil at the same daily rate as has been measured in young children (100 mg soil/day) but that they ingest soil less frequently than young children. Older children (ages 7 to 18) are assumed to be in prolonged contact with soil for one day per week. This is equal to 52 days per year. Older children are assumed to have decreased exposure compared to younger children. In addition to some of the factors mentioned above for younger children, as a child gets older, he or she is more likely to spend more time off-site visiting more interesting areas, engaging in after school or other civic activities, and participating in organized sports. Thus, the risk assessment assumes that older children are exposed only one day per week. As with younger children, the exact amount of time an older child spends on site in prolonged contact with soil can only be accurately determined by direct observation.

Adults are assumed to be in prolonged contact with on-site soil only 26 days per year. This is equivalent to one day a week for half of the weeks out of the year. This frequency of exposure may be typical of an adult who does yard work for six months out of the year. Children, ages 2 to 6, are assumed to weigh 17 kilograms. Older children are assumed to weigh 50 kilograms. Adults are assumed to weigh 70 kilograms. The exposure assumptions used are listed in Table 2-6.

PCOC intake via inadvertent soil ingestion by children and adults living in the hypothetical development at the South Cavalcade Site was estimated based on two valid samples in which no organic PCOCs were detected. The risk assessment assumes that all of a child's and adult's on-site outdoor time is spent on the most contaminated parts of the South Cavalcade Site. At the South Cavalcade Site, only two relatively small areas were observed to have visible surface soil staining; thus if the Site were to be developed, most residents would have no exposure and no risk. Only those few residents whose property contained all or part of the stained areas would be potentially exposed if the soiled areas were not built upon or paved over and otherwise exposed. Additionally, the assumptions used to estimate dermal adsorption and inadvertent soil ingestion are very conservative and result in an overestimate of exposure for all residents, but do provide an upper bound for potential exposures assuming the two soil samples represent the maximum. If these samples do not, then the upper bound risk would be higher. Thus, because the exposure assumptions are possible but very unlikely, this scenario is conservative.

Potential Dermal Exposure to PCOCs in Soil. Potential dermal exposure to PCOCs in soil was estimated for the same age groups as for potential exposure through soil ingestion (children ages 2 through 6, 7 through 18, and adults ages 19 and older). Assumptions identical to the inadvertent soil ingestion scenario were also made for years lived as a residential occupant on the South Cavalcade Site, time spent on the site, body weight, and for PCOC concentration in soil (see Table 2-6 for a list of exposure assumptions).

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Assessment of PCOC intake through dermal contact with contaminated soil required estimation of three new parameters: the amount of skin in contact with soil; the amount of soil on skin; and the rate of absorption of PCOCs through intact skin.

The risk assessment assumes that every day a younger child goes outdoors to play, he or she covers the entire surface area of both of his or her hands, half of the entire surface area of both of his or her arms, half of the entire surface area of both of his or her legs, and half of the entire surface area of both of his or her feet with soil. The total exposed surface area is assumed to be 2070 cm^2 (Anderson et al., 1985). Half of the surface area of a child's arms corresponds to a child getting soil on one side of his or her arm from hand to shoulder or to getting soil on all sides of both arms up to the elbow. The assumed exposures for a child's legs can be described similarly. Getting soil over one half of the surface area of a child's feet corresponds to a child walking barefoot every time he or she goes outside to play. The above assumptions for quantifying the amount of a child's surface area exposed to soil contact are likely to overestimate exposure since they assume that every time a child goes outside he or she will: (1) get soil on the exposed area of skin; and (2) his or her arms, legs, and feet will be uncovered. In many instances this will not be the case because only a portion of a child's appendages will be uncovered.

Older children (ages 7 through 18) are assumed to have a smaller proportion of their body surface area exposed to soil. The risk assessment assumes that only one half of the entire surface area of both an older child's hands will be covered with soil. For example, only the palms will have soil adhering to them. The risk assessment further assumes that one quarter of the entire surface area of an older child's arms and legs will come into contact with contaminated soil from the site. This corresponds to the fronts of both shins and both forearms being exposed to soil on the site. The total exposed surface area of an older child is 1880 cm^2 (Anderson et al., 1985). Adult residents (ages 18 through 70) are assumed to have one half of the entire surface of both of their hands come into contact with soil and also one quarter of the entire surface area of both of their arms. Thus the exposed area of adults is assumed to be 1120 cm^2 (Anderson et al. 1985).

The risk assessment assumes that a person's skin has 0.5 milligrams of soil per square centimeter when soiled. This is based on the study of Lepow et al. (1975) that used tape to take soil off of the hands of children and determined that approximately 0.5 milligrams of soil per cm^2 adhered to a child's hand. A recent review of assumptions used for polychlorinated dibenzodioxins (PCDDs) in soil risk assessments also reported that 0.5 mg soil/cm^2 is a realistic estimate of the amount of soil on skin (Paustenbauch et al., 1986).

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Little information about dermal absorption is available for most of the PCOCs and for most organic compounds, especially when adsorbed onto soil as they might be at the South Cavalcade Site. Measurements of the dermal absorption of several organic compounds and pesticides dissolved in acetone, applied on the forearms of human subjects and allowed to remain in contact with skin for 24 hours have revealed a large range in absorption varying from less than a percent of the applied dose (diquat, hippuric acid, nicotinic acid, and thiourea) to over fifty percent of the applied dose (carbaryl and dinitrochlorobenzene) (Feldman and Maibach 1970, 1974). The average absorption for the 33 compounds tested was 15 percent. Note that this value is for compounds dissolved in a solvent and then applied directly to the skin for a 24-hour period. Dissolution of PCOCs in an organic solvent greatly increases compound mobility when compared to adsorption on soil. These conditions would not be representative of exposures at the South Cavalcade Site where contaminants have been mixed with and adsorbed onto soil for over 25 years, where exposure duration will be much shorter because soil will be washed off when bathing, and where areas of skin with varying absorptive capacity will be exposed. All of these factors will serve to decrease the amount of PCOCs potentially absorbed from soil at the South Cavalcade Site.

The effect of adsorption of PCOCs onto soil can be taken into account, in part, by using the results of Poiger and Schlatter (1980). They applied dioxin diluted in various solvents and also dioxin diluted in water and soil to the skin of rats. Absorption from the soil and water

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application reportedly ranged from 0.05 percent to 2 percent and was between 9 and 330 times lower than from the solvent application. Longer soil-contaminant contact times and lower doses, both of which may occur at the South Cavalcade Site, served to decrease the amount of dioxin absorbed. Combining the results from the above experiments suggests that absorption of organic compounds from soils may vary from about 2.0 percent to much less than 0.1 percent and has a geometric mean of about 0.3 percent. True rates of absorption are likely to be even lower than the range listed above because people on the site are not exposed for 24 hours at a time and because some of the organic PCOCs, i.e., PAHs, have a high affinity for soil adsorption and have been in contact with soil for many years. To be protective of public health, the risk assessment uses an absorption adjustment factor of 1 percent for organic PCOCs in soil, this factor is about three times greater than the geometric mean of absorption rates described above. Dermal absorption of inorganic contaminants is assumed to be negligible compared to other exposure routes (U.S. EPA 1981; U.S. EPA 1984d; U.S. EPA 1984e; U.S. EPA 1984f). 007701

The PCOC concentrations used to estimate contaminant intake for this exposure scenario through potential dermal exposure to contaminated surficial soil are shown in Table 2-11. Also shown in Table 2-11 are the corresponding contaminant intakes for younger children ages 2 through 6, older children ages 7 through 18, and for adults.

Potential Total Contaminant Intake. An average daily lifetime potential contaminant intake can be calculated for the worst case hypothetical exposure scenario for residential occupants at the South Cavalcade Site by summing the potential intakes from inadvertent soil ingestion and dermal exposure to contaminants. In calculating these potential intakes, degradation of PAHs in soils was included. Appendix 2-B presents the method used to calculate average soil concentrations that include degradation. The half life used for PAHs in soils is 3.8 years, as discussed in Appendix 2-C. The concentrations used in the intake calculations and the results of the intake calculations are shown in Table 2-11.

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Table 2-11

POTENTIAL HYPOTHETICAL FUTURE RESIDENTIAL INTAKES

The potential intake of every detected PCOC is shown for a person living in a residential area developed on the present South Cavalcade Site and potentially exposed to PCOCs from the South Cavalcade Site under hypothetical future conditions. Potential intake is broken down by PEP and by age of person being exposed. The last column shows the potential daily lifetime intake. PCOC concentrations used to generate the potential intakes are shown in the second column.

PCOC	PCOC Concentration (mg/kg soil)	Potential Lifetime Soil Ingestion: Young Child (mg/kg/day)	Potential Lifetime Soil Ingestion: Older Child (mg/kg/day)	Potential Lifetime Soil Ingestion: Adult (mg/kg/day)	Potential Lifetime Dermal Intake: Young Child (mg/kg/day)	Potential Lifetime Dermal Intake: Older Child (mg/kg/day)	Potential Lifetime Dermal Intake: Adult (mg/kg/day)	Potential Total Lifetime Intake (mg/kg/day)
Total PAH (a)	6.21	1.29E-06	3.03E-07	4.69E-07	1.33E-07	2.85E-08	2.63E-08	2.25E-06
Pot. Carc. PAH (a,b)	2.07	4.29E-07	1.01E-07	1.56E-07	4.44E-08	9.50E-09	8.76E-09	7.49E-07
Arsenic	8.8	1.82E-06	4.30E-07	6.65E-07	0.00E+00	0.00E+00	0.00E+00	2.92E-06
Chromium	9.5	1.97E-06	4.64E-07	7.18E-07	0.00E+00	0.00E+00	0.00E+00	3.15E-06
Copper	5	1.04E-06	2.44E-07	3.78E-07	0.00E+00	0.00E+00	0.00E+00	1.66E-06
Lead	30.4	6.30E-06	1.48E-06	2.30E-06	0.00E+00	0.00E+00	0.00E+00	1.01E-05
Zinc	3480	7.21E-04	1.70E-04	2.63E-04	0.00E+00	0.00E+00	0.00E+00	1.15E-03

(a): Concentration values reflect degradation considerations using a 3.8 year half-life for PAHs.
(b): See Table 2-2 for a list of potentially carcinogenic PAH.

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2.2.4 Potential Maximum Concentration Exposure Scenario for Sediment

2.2.4.1 Potential Intakes

Older Children

The presence of fences surrounding the northern and southern areas would tend to deter younger children, ages 2 to 6, from gaining access to the property. In addition, access to the unfenced central area by the same age group was assumed very unlikely because of several railroad lines located on its western border. Younger children are not likely to be playing near an area of high density railroad activity. The fence was assumed to deter adults from trespassing on the property. The barbed wire fences surrounding the northern and southern areas were assumed to deter older children from trespassing on those portions of the South Cavalcade Site, but not from the boundaries where the drainage ditch is located that manages the surface water run-off from the Site. In addition, this age group could potentially contact the ditches located in the unguarded central area.

Potential Inadvertent Ingestion of PCOCs in Sediments. Potential current exposures to PCOCs in sediments via inadvertent ingestion and dermal contact were estimated for the South Cavalcade Site. Older children were assumed to contact sediments once a month, every month of the year or 12 days per year for 12 years. Other exposure assumptions are identical to those used for estimating exposure to soils in other scenarios (Table 2-6). Current exposures were estimated for maximum and minimum PCOC concentrations in sediments to provide a range of potential exposure. The estimated maximum intake of PCOCs from sediments is shown in Table 2-12 along with the maximum PCOC concentrations.

Potential Dermal Exposure to PCOCs in Sediments. When on the site, older children were assumed to have a total surface area of 1880 cm^2 exposed to sediment (one half of the surface area of hands and one quarter the surface area of legs and arms) and that 0.5 milligrams of soil adhered to each square centimeter of skin (see Table 2-6 for exposure assumptions). Dermal exposure was estimated using the formula described earlier.

Potential Total Contaminant Intake. Dermal contact and inadvertent ingestion exposures for current conditions were estimated for maximum PCOC concentrations at the South Cavalcade Site. These estimates should provide an upper bound range of potential exposure

Table 2-12

POTENTIAL MAXIMUM SEDIMENT INTAKES

Potential daily intake, averaged over a lifetime, of every detected PCOC is shown for an older child, age 7-17, potentially exposed to maximum PCOC concentration in sediments while trespassing under current conditions. Potential intake is broken down by PEP. The last column shows the potential daily lifetime intake. PCOC concentrations used to generate the potential intakes are shown in the second column. PCOCs not listed were not detected.

PCOC	Maximum Concentration (mg/kg sediment)	Lifetime Ingestion Intake Older Child (mg/kg/day)	Lifetime Dermal Intake Older Child (mg/kg/day)	Potential Total Lifetime Intake (mg/kg/day)
Total PAH	10.2	1.15E-07	1.08E-08	1.26E-07
Pot. Carc. PAH (a)	5.825	6.57E-08	6.17E-09	7.18E-08
Arsenic	34	3.83E-07	0.00E+00	3.83E-07
Chromium	360	4.06E-06	0.00E+00	4.06E-06
Copper	89	1.00E-06	0.00E+00	1.00E-06
Lead	540	6.09E-06	0.00E+00	6.09E-06
Zinc	3300	3.72E-05	0.00E+00	3.72E-05

(a) See Table 2-2 for the list of potentially carcinogenic PAH.

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and risks. The maximum PCOC concentrations found in sediment are presented in Table 2-12. The total potential current intakes of each PCOC broken down by PEPs are also shown in Table 2-12 for maximum sediment PCOC concentrations. Degradation of PCOCs was not considered in the sediment scenario. Thus, potential future intakes were assumed to be identical to current future intakes. For those sediment samples where PCOC concentrations were non-detectable, surrogate concentrations were based on one-half the analytical laboratory detection limit.

2.2.5 Potential Minimum Concentration Exposure Scenario for Sediment

2.2.5.1 Potential Intakes

The approach used to derive potential current PCOC intake estimates for the minimum concentration scenario was identical to that used to derive potential current exposures for the maximum exposure scenarios for sediment. Differences in potential exposure are due to the use of alternative PCOC concentrations in sediment. The concentrations used to estimate potential current intakes for the minimum concentration scenario are shown in Table 2-13 along with the estimated potential current intakes. As with current intakes, degradation was not accounted for and future intakes are assumed to be identical to current intakes.

2.2.6 Hypothetical Future Exposures to Groundwater

In the event that the South Cavalcade Site is developed for residential or commercial purposes, residential and commercial occupants could potentially be exposed to PCOCs through ingestion of groundwater. At present, nearby residents obtain their drinking water from the municipal well which extracts water from aquifers 1000 feet or more beneath the surface. The pumping wells for this municipal supply are located over 10 miles from the South Cavalcade site.

As previously discussed in Section 2.2.1.3 (PEPs associated with groundwater), no PCOCs have been detected in the aquifer at 175 feet and, consequently, no current risk exists. However, if migration of PCOCs with vertical and horizontal groundwater flow occurs in the future, potential intakes of PCOCs in drinking water could potentially occur via future hypothetical wells (see Situations 1, 2 and 3 depicted in Figure 2-1). As discussed in Section

Table 2-13

POTENTIAL MINIMUM SEDIMENT INTAKES

Potential daily intake, averaged over a lifetime, of every detected PCOC is shown for a child, aged 2-18, potentially exposed to minimum PCOC concentration in sediments under current conditions. Potential intake is broken down by PEP and by age of the person being exposed. The last column shows the potential daily lifetime intake. PCOC concentrations used to generate the potential intakes are shown in the second column. PCOCs not listed were not detected.

PCOC	Minimum Concentration (mg/kg sediment)	Lifetime Ingestion Intake Older Child (mg/kg/day)	Lifetime Dermal Intake Older Child (mg/kg/day)	Potential Total Lifetime Intake (mg/kg/day)
Total PAH	2.8	3.16E-08	2.97E-09	3.45E-08
Pot. Carc. PAH (a)	0.99	1.12E-08	1.05E-09	1.22E-08
Arsenic	1	1.13E-08	0.00E+00	1.13E-08
Chromium	1	1.13E-08	0.00E+00	1.13E-08
Copper	2.5	2.82E-08	0.00E+00	2.82E-08
Lead	10	6.54E-07	0.00E+00	1.13E-07
Zinc	58	6.54E-07	0.00E+00	6.54E-07

(a) See Table 2-2 for the list of potentially carcinogenic PAH.

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2.2.1.3, accurate evaluation of these migration pathways is not possible. Consequently, although intake of PCOCs can potentially occur in the future via these three PEPs, PCOCs were assumed, for the purposes of estimating a worst case exposures, to migrate to the points of exposure at concentrations equal to those observed during the Remedial Investigation in the 10 foot and 50 foot sands. The concentrations used to estimate potential current outakes are shown in Tables 2-13A & 2-13B along with the estimated potential intakes.

2.3 Risk Characterization

2.3.1. Introduction

Two general types of health risks are characterized for each of the potential exposure scenarios: potential carcinogenic risks and non-carcinogenic risks from chronic exposures. Potential carcinogenic risks are estimated by multiplying the intakes derived in Section 2.2 by the upper 95 percent bound of the carcinogenic potency estimate derived by the U.S. EPA. Potential carcinogenic risks are expressed as the excess hypothetical chance, over and above the background cancer rate, that a person has of getting cancer over the course of a lifetime (70 years). 007707

The potential for people to be adversely affected by non- carcinogenic PCOCs if chronically exposed is determined by comparing the intakes of PCOCs estimated in Section 2.2 to acceptable chronic intakes (AIC) derived by the U.S. EPA (presented in Table 2-1). The results of this comparison can be expressed as a Hazard Index (HI) which is a measure of the potential for adverse health effects to occur. The HI is equal to the estimated intake divided by the AIC. When this ratio exceeds unity, the estimated intake is greater than the allowable intake and a potential for adverse health effects may exist. When it is less than one, the estimated intake is less than the allowable intake and no adverse health effects are expected. Note that for some compounds sufficient information does not exist to develop AICs and thus their potential to cause adverse health effects cannot be evaluated.

In this section of the final PHEA, the potential for adverse health effects is first discussed for the maximum concentration exposure scenario involving surficial soils at the South Cavalcade Site. Potential carcinogenic and noncarcinogenic adverse health effects are discussed for potential exposure to sediments, based on the maximum and minimum PCOC concentrations. The results are summarized in Section 2.3.10.

Table 2-13A

POTENTIAL MAXIMUM HYPOTHETICAL GROUND-WATER INTAKES

Potential intake of every PCOC is shown for a person hypothetically exposed to the maximum of PCOC groundwater concentrations. PCOCs not listed were not detected.

PCOC	Maximum Concentration (mg/l)	Hypothetical PCOC Intake (mg/kg/day)	Potential Daily Intake Total (mg/kg/day)
Total PAH	8.714	2.49E-01	2.49E-01
Pot. Carc. PAH (a)	0.104	2.97E-02	2.97E-02
Arsenic	0.522	2.49E-01	2.49E-01
Chromium	0.45	1.49E-02	1.49E-02
Copper	1.34	1.29E-02	1.29E-02
Zinc	1.18	3.83E-02	3.83E-02
Benzene	0.93	3.37E-02	3.37E-02
Ethylbenzene	0.48	2.66E-02	2.66E-02
Toluene	1	1.37E-02	1.37E-02
Xylene	1.1	2.86E-02	2.86E-02

(a): See Table 2-2 for a list of potentially carcinogenic PAHs.

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Table 2-13B

POTENTIAL MINIMUM HYPOTHETICAL GROUND-WATER INTAKES

Potential intake of every PCOC is shown for a person hypothetically exposed to the minimum PCOC ground-water concentrations. PCOCs not listed were not detected.

PCOC	Minimum Concentration (mg/l)	Hypothetical PCOC Intake (mg/kg/day)	Potential Daily Intake Total (mg/kg/day)
Total PAH	0.03	8.57E-04	8.57E-04
Pot. Carc. PAH (a)	0.08	2.86E-04	2.86E-04
Arsenic	0.03	8.57E-04	8.57E-04
Chromium	0.005	1.43E-04	1.43E-04
Copper	0.005	1.43E-04	1.43E-04
Zinc	0.125	3.57E-03	3.57E-03
Benzene	0.01	2.86E-04	2.86E-04
Ethylbenzene	0.0025	7.14E-05	7.14E-05
Toluene	0.0025	7.14E-05	7.14E-05
Xylene	0.0025	7.14E-05	7.14E-05

(a) See Table 2-2 for a list of potentially carcinogenic PAH.

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2.3.2 Potential Health Risks from Exposure to Surface and Surficial Soils

2.3.2.1 Potential Carcinogenic Risks

Estimates of the upper bound excess lifetime potential carcinogenic risk of a utility worker exposed to PCOC concentrations in surface and surficial soils at the South Cavalcade Site are presented in Table 2-14 for potential current and future exposures. Table 2-15 presents the potential current and future risks to construction workers working on the site and exposed to PCOCs in surface and surficial soils. Potential current risks from PCOCs in surface soils to commercial occupants are presented in Table 2-16 and potential future risks to commercial occupants are presented in Table 2-17. Risks from PCOCs in surface soils to hypothetical residents living in a hypothetical future residential development on the site are presented in Table 2-18.

It is important to recognize that the potential current risks presented in Tables 2-14, 2-15, and 2-16 are not necessarily representative of the potential risks to the average utility worker, construction worker or the average commercial occupant. Potential exposures in these scenarios were developed using the only valid data, two surficial samples, each with non-detectable levels of PAHs, thereby limiting the accuracy of the risk estimates for these PCOCs. The concentration used in the risk characterization for the PAHs was assumed to be half the reported detection limit to provide an estimate of the PCOC concentrations in these samples. These samples provide an upper bound estimate of potential risks to a utility worker, construction worker, or commercial occupant visiting the portions of the site where the samples were taken. Actual risks to utility workers, construction workers and commercial occupants could be higher or lower depending upon the areas of the site they contact. A commercial occupant who never visits and contacts visibly contaminated soils would likely have much lower risks than estimated in this risk assessment. Similarly, a commercial occupant who visits the visibly stained areas at a greater frequency than assumed in the risk assessment could have higher potential risks. The reader should also note that some of the commercial buildings on-site cover soils that may contain PCOCs. The concentration of PCOCs in these soils is not known at this time. Future risks to people on-site could be higher or lower depending upon the PCOC concentration in these soils and the disposition of these soils if they were to be exposed. Sources of uncertainty that could lead to overestimation and underestimation of potential adverse health effects are discussed in Section 2.5.

Table 2-14

POTENTIAL UTILITY WORKER RISKS (e)

The hazard index for potential chronic effects and the 95% upper bound excess lifetime cancer risk is shown for a utility worker potentially exposed to surficial soil containing PCOC concentrations at the South Cavicade Site under current conditions. The potential total intake and its breakdown by PEP is also shown.

PCOC	Potential Chronic Intake: Total Intake (mg/kg/day)	Percent Due To Soil Ingestion	Percent Due To Dermal Contact	Percent Due To Inhalation	Potential Threshold Effects: Acceptable Chronic Intake Inhalation (mg/kg/day)	Acceptable Chronic Intake Ingestion (mg/kg/day)	Hazard Index	Potential Cancer Risk: Carcinogenic Potency Factor Inhalation (day-kg/mg)	Carcinogenic Potency Factor Ingestion (day-kg/mg)	Excess Lifetime Cancer Risk
Total PAH	5.64E-08	86.24%	9.62%	4.14%	(a)	(a)	(a)	(b)	(b)	(b)
Pot.Carc. PAH (f)	1.88E-08	86.24%	9.62%	4.14%	(a)	(a)	(a)	6.11E+00	1.15E+01	2.12E-07
Arsenic	5.16E-09	95.42%	0.00%	4.58%	(a)	(a)	(a)	5.00E+00	1.50E+00	8.56E-09
Chromium	5.57E-09	95.42%	0.00%	4.58%	(a)	5.00E-03	7.56E-08	8.00E+00	(b)	2.04E-09
Copper	2.93E-09	95.42%	0.00%	4.58%	1.00E-02	3.70E-02	8.90E-08	(b)	(b)	(b)
Lead	1.78E-08	95.42%	0.00%	4.58%	4.30E-04	1.40E-03	1.40E-05	(b)	(b)	(b)
Zinc	2.04E-06	95.42%	0.00%	4.58%	(d)	2.10E-01	9.71E-06	(b)	(b)	(b)
						Summed Index:	2.39E-05		Summed Risk:	2.23E-07

(a): EPA has not derived an AIC for that compound.
(b): The compound is not considered to be carcinogenic through this route.
(c): The AIC for chromium VI was used in the table.
(d): EPA has not derived an AIC for that compound via inhalation. Therefore, the AIC for ingestion is used for potential exposures from inhalation.
(e): The future exposure scenario for utility workers is assumed to be identical.
(f): See Table 2-2 for a list of potentially carcinogenic PAH.

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Table 2-15

POTENTIAL RISKS FOR FUTURE CONSTRUCTION WORKERS

The hazard index for potential chronic effects and the 95% upper bound excess lifetime cancer risk is shown for a construction worker potentially exposed to surficial soil containing PCOC concentrations at the South Cavicade Site under current conditions. The potential total intake and its breakdown by PEP is also shown.

PCOC	Potential Chronic Intake: Total Intake (mg/kg/day)	Percent Due To Soil Ingestion	Percent Due To Dermal Contact	Percent Due To Inhalation	Potential Threshold Effects: Acceptable Chronic Intake Inhalation (mg/kg/day)	Acceptable Chronic Intake Ingestion (mg/kg/day)	Hazard Index	Potential Cancer Risk: Carcinogenic Potency Factor Inhalation (day-kg/mg)	Carcinogenic Potency Factor Ingestion (day-kg/mg)	Excess Lifetime Cancer Risk
Total PAH	1.10E-06	86.24%	9.62%	4.14%	(a)	(a)	(a)	(b)	(b)	(b)
Pot.Carc. PAH (f)	3.67E-07	86.24%	9.62%	4.14%	(a)	(a)	(a)	6.11E+00	1.15E+01	4.13E-06
Arsenic	1.01E-07	95.42%	0.00%	4.58%	(a)	(a)	(a)	5.00E+00	1.50E+00	1.67E-07
Chromium	1.09E-07	95.42%	0.00%	4.58%	(a)	5.00E-03	1.47E-06	8.00E+00	(b)	3.98E-08
Copper	5.71E-08	95.42%	0.00%	4.58%	1.00E-02	3.70E-02	1.74E-06	(b)	(b)	(b)
Lead	3.47E-07	95.42%	0.00%	4.58%	4.30E-04	1.40E-03	2.74E-04	(b)	(b)	(b)
Zinc	3.98E-05	95.42%	0.00%	4.58%	(d)	2.10E-01	1.89E-04	(b)	(b)	(b)
						Summed Index:	4.66E-04		Summed Risk:	4.34E-06

(a): EPA has not derived an AIC for that compound.
(b): The compound is not considered to be carcinogenic through this route.
(c): The AIC for chromium VI was used in the table.
(d): EPA has not derived an AIC for that compound via inhalation. Therefore, the AIC for ingestion is used for potential exposures from inhalation.
(e): See Table 2-2 for a list of potentially carcinogenic PAH.

Table 2-16

POTENTIAL ON-SITE WORKER (COMMERCIAL OCCUPANT) RISKS (e)

The hazard index for potential chronic effects and the 95% upper bound excess lifetime cancer risk is shown for an on-site worker (commercial occupant) potentially exposed to PCOC surficial soil concentrations at the South Cavicade Site under current conditions. The potential total intake and its breakdown by PEP is also shown.

	Potential Lifetime Chronic Intakes			Potential Threshold Effects		Potential Cancer Risk	
PCOC	Total Intake (mg/kg/day)	Percent Due To Soil Ingestion	Percent Due To Dermal Contact	Acceptable Chronic Intake (mg/kg/day)	Hazard Index	Carcinogenic Potency Factor (day-kg/mg)	Excess Lifetime Cancer Risk
Total PAH	3.24E-07	89.97%	10.03%	(a)	(a)	(b)	(b)
Pot.Carc. PAH (f)	9.89E-08	98.36%	10.97%	(a)	(a)	1.15E+01	1.14E-06
Arsenic	2.95E-08	100.00%	0.00%	(a)	(a)	1.50E+00	4.43E-08
Chromium	3.19E-08	100.00%	0.00%	5.00E-03	6.37E-06	(b)	(b)
Copper	1.68E-08	100.00%	0.00%	3.70E-02	4.53E-07	(b)	(b)
Lead	1.02E-07	100.00%	0.00%	1.40E-03	7.28E-05	(b)	(b)
Zinc	1.17E-05	100.00%	0.00%	2.10E-01	5.56E-05	(b)	(b)
				Summed Index:	1.35E-04	Summed Risk:	1.18E-06

(a): EPA has not derived an AIC for that compound.
(b): The compound is not considered to be carcinogenic through this route.
(c): The AIC for chromium VI was used in the table.
(d): EPA has not derived an AIC for that compound via inhalation. Therefore, the AIC for ingestion is used for potential exposures from inhalation.
(e): The exposure scenario for on-site, commercial occupants is assumed to take place under current conditions. On-site worker exposure assumptions are presented in Table 2-6.
(f): See Table 2-2 for a list of potentially carcinogenic PAH.

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Table 2-17

POTENTIAL ON-SITE WORKER (COMMERCIAL OCCUPANT) FUTURE RISKS (e)

The hazard index for potential chronic effects and the 95% upper bound excess lifetime cancer risk is shown for an on-site worker (commercial occupant) potentially exposed to surficial soil containing PCOC concentrations at the South Cavlcade Site under current conditions. The potential total intake and its breakdown by PEP is also shown.

	Potential Lifetime Chronic Intakes			Potential Threshold Effects		Potential Cancer Risk	
PCOC	Total Intake (mg/kg/day)	Percent Due To Soil Ingestion	Percent Due To Dermal Contact	Acceptable Chronic Intake (mg/kg/day)	Hazard Index	Carcinogenic Potency Factor (day-kg/mg)	Excess Lifetime Cancer Risk
Total PAH	8.29E-08	98.36%	10.97%	(a)	(a)	(b)	(b)
Pot.Carc. PAH (f,g)	2.76E-08	98.36%	10.97%	(a)	(a)	1.15E+01	3.18E-07
Arsenic	2.95E-08	100.00%	0.00%	(a)	(a)	1.50E+00	4.43E-08
Chromium	3.19E-08	100.00%	0.00%	5.00E-03	6.37E-06	(b)	(b)
Copper	1.68E-08	100.00%	0.00%	3.70E-02	4.53E-07	(b)	(b)
Lead	1.02E-07	100.00%	0.00%	1.40E-03	7.28E-05	(b)	(b)
Zinc	1.17E-05	100.00%	0.00%	2.10E-01	5.56E-05	(b)	(b)
				Summed Index:	1.35E-04	Summed Risk:	3.62E-07

(a): EPA has not derived an AIC for that compound.
(b): The compound is not considered to be carcinogenic through this route.
(c): The AIC for chromium VI was used in the table.
(d): EPA has not derived an AIC for that compound via inhalation. Therefore, the AIC for ingestion is used for potential exposures from inhalation.
(e): The exposure scenario for on-site, commercial occupants is assumed to take place under current conditions. On-site worker exposure assumptions are presented in Table 2-6.
(f): See Table 2-2 for a list of potentially carcinogenic PAH.
(g): Degradation has been accounted for based on a 3.8 half-life for PAHs and a 20 year work career.

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Table 2-18

POTENTIAL HYPOTHETICAL FUTURE RESIDENTIAL RISKS

The hazard index for potential chronic effects (column 6) and the 95% upper bound excess lifetime cancer risk (column 8) is shown for a hypothetical resident potentially exposed to soil concentrations containing PCOCs at the South Cavalcade Site under future conditions. Potential total intake and its breakdown by PEP is also shown.

	Potential Lifetime Chronic Intake			Potential Threshold Effects		Potential Cancer Risk	
PCOC	Total (mg/kg/day)	Percent Due To Soil Ingestion	Percent Due To Dermal Contact	Acceptable Chronic Intake (mg/kg/day)	Hazard Index	Carcinogenic Potency Factor (day-kg/mg)	Excess Lifetime Cancer Risk
Total PAH (c)	2.25E-06	91.64%	8.36%	(a)	(a)	(b)	(b)
Pot. Carc. PAH (c,d)	7.49E-07	91.64%	8.36%	(a)	(a)	1.15E+01	8.62E-06
Arsenic	2.92E-06	100.00%	0.00%	(a)	(a)	1.50E+00	4.38E-06
Chromium (e)	3.15E-06	100.00%	0.00%	5.00E-03	6.30E-04	(b)	(b)
Copper	1.66E-06	100.00%	0.00%	3.70E-02	4.48E-05	(b)	(b)
Lead	1.01E-05	100.00%	0.00%	1.40E-03	7.20E-03	(b)	(b)
Zinc	1.15E-03	100.00%	0.00%	2.10E-01	5.50E-03	(b)	(b)
				Summed Index =	6.17E-03	Summed risk =	1.30E-05

(a): EPA has not derived an AIC for that compound.
(b): The compound is not considered to be carcinogenic through the oral route.
(c): Degradation has been accounted for using a half-life of 3.8 years for PAHs.
(d): See Table 2-2 for a list of potentially carcinogenic PAH.
(e): The AIC for chromium VI was used in the table.

Three PCOCs (potentially carcinogenic PAHs, arsenic, and chromium) contribute to the potential future summed risk of about two in ten million (2 x 10^{-7}) for utility workers, however; the risks estimated from potentially carcinogenic PAHs are the largest and make up more than 95 percent of the summed risk. Arsenic and chromium make up the remainder of the risk. Table 2-14 also indicates that inadvertent ingestion of soil accounts for the majority of a person's potential lifetime intake of PCOCs.

Three PCOCs (potentially carcinogenic PAHs, arsenic and chromium) contribute to the potential future summed risk of about 4 in a million (4 x 10^{-6}) for construction workers. However, the risks estimated from potentially carcinogenic PAHs are the largest and make up 95 percent of the summed risk. Table 2-15 indicates inadvertent ingestion of soil accounts for the majority of a person's potential lifetime intake of PCOCs.

The total excess lifetime cancer risk for commercial occupants associated with current exposures, presented in Table 2-16, is 1 x 10^{-6}. Arsenic and potentially carcinogenic PAH are the only two PCOCs that contribute to the risk. The total excess lifetime cancer risk for future commercial occupant exposure is 3 x 10^{-7} (Table 2-17). Potentially carcinogenic PAHs contribute 95 percent of the risk in the current exposure scenario, while potentially carcinogenic PAH contribute 87.5 percent in the future exposure scenario.

The potential carcinogenic risks for hypothetical future residents exposed to PCOCs in South Cavalcade soils are shown in Table 2-18. Two PCOCs (potentially carcinogenic PAHs and arsenic) contribute to the summed risk of 1 x 10^{-5}. Potentially carcinogenic PAHs contribute approximately 66 percent of the risk, while arsenic contributes approximately 33 percent.

2.3.2.2 Potential Non-carcinogenic Chronic Risks

Estimates of the potential for current and future non-carcinogenic adverse health effects to utility workers and construction workers on site caused by potential chronic exposure to PCOCs at the South Cavalcade Site are shown in Table 2-14 and Table 2-15. The risks to current commercial occupants, future commercial occupants, and hypothetical future residents are presented in Table 2-16, Table 2-17, and Table 2-18, respectively.

The hazard indices for individual PCOCs and the summed hazard index of 0.0000239 for current and future utility worker exposures do not exceed one and thus indicate that little

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potential for non-carcinogenic adverse health effects exists (Table 2-14). The hazard indices for current and future construction worker exposures are also less than one (Table 2-15) indicating that little potential exists for the occurrence of adverse health effects. The hazard indices for both individual and summed non-carcinogenic risks for current and future commercial occupants do not exceed one (0.0000257 and 0.0000271, respectively) also indicating that little or no potential for non-carcinogenic adverse health effects exists for this group of receptors (Table 2-16 and Table 2-17).

The non-carcinogenic health risks for hypothetical future residents exposed to PCOCs in South Cavalcade surface soils are shown in Table 2-18. Neither the hazard index for individual PCOCs, nor all PCOCs summed, exceeds unity (0.00617), indicating that little potential for non-carcinogenic adverse health effects exists.

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2.3.3 Potential Health Risks for the Maximum and Minimum Exposure Scenario to Sediments

2.3.3.1 Potential Carcinogenic Risks

Estimates of the potential carcinogenic risks caused by potential exposure to maximum and minimum PCOC concentrations in sediments are presented in Table 2-19 and Table 2-20, respectively. The total estimated upper 95% bound excess lifetime cancer risk, assuming the exposure assumptions described in Section 2.2.8, ranges from about 1×10^{-7} to 1×10^{-6}. Potential current and future risks are not differentiated because current and future exposures were assumed to be identical.

2.3.3.2 Potential Non-Carcinogenic Risks

Estimates of the hypothetical future non-carcinogenic risks caused by potential exposures to maximum and minimum PCOC concentrations in sediments are presented in Table 2-19 and Table 2-20, respectively. Neither the total HI nor individual HIs exceed one. The HI for potential maximum PCOC concentrations in sediment is 0.00536; the HI for potential minimum PCOC concentrations in sediment is 0.0000866. Thus, little potential exists for non-carcinogenic adverse health effects to be caused by maximum or minimum PCOC concentrations in sediments. Potential current and future risks are not differentiated because current and future exposures were assumed to be identical.

Table 2-19

POTENTIAL MAXIMUM SEDIMENT RISKS

The hazard index for potential chronic effects (column 6) and the 95% upper bound excess lifetime cancer risk (column 8) is shown for an older child, age 7 through 18, potentially exposed to maximum PCOC sediment concentrations under current conditions. Potential total intake and its breakdown by PEP is also shown. PCOCs not listed were not detected.

	Potential Lifetime Chronic Intake			Potential Threshold Effects		Potential Cancer Risk	
PCOC	Total (mg/kg/day)	Percent Due To Sediment Ingestion	Percent Due To Dermal Contact	Acceptable Chronic Intake (mg/kg/day)	Hazard Index	Carcinogenic Potency Factor (day-kg/mg)	Excess Lifetime Cancer Risk
Total PAH	1.26E-07	91.41%	8.59%	(a)	(a)	(b)	(b)
Pot. Carc. PAH (c)	7.18E-08	91.41%	8.59%	(a)	(a)	1.15E+01	8.26E-07
Arsenic	3.83E-07	100.00%	0.00%	(a)	(a)	1.50E+00	5.75E-07
Chromium (d)	4.06E-06	100.00%	0.00%	5.00E-03	8.12E-04	(b)	(b)
Copper	1.00E-06	100.00%	0.00%	3.70E-02	2.71E-05	(b)	(b)
Lead	6.09E-06	100.00%	0.00%	1.40E-03	4.35E-03	(b)	(b)
Zinc	3.72E-05	100.00%	0.00%	2.10E-01	1.77E-04	(b)	(b)
				Summed Index =	5.36E-03	Summed risk =	1.40E-06

(a): EPA has not derived an AIC for that compound.
(b): The compound is not assumed to be carcinogenic through the oral and dermalroute.
(c): See Table 2-2 for the list of potentially carcinogenic PAH.
(d): The AIC for chromium VI was used in the table.

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Table 2-20

POTENTIAL MINIMUM SEDIMENT RISKS

The hazard index for potential chronic effects (column 6) and the 95% upper bound excess lifetime cancer risk (column 8) is shown for a child, aged 2 through 18, potentially exposed to minimum PCOC sediment concentrations under current conditions. Potential total intake and its breakdown by PEP is also shown. PCOCs not listed were not detected.

PCOC	Potential Lifetime Chronic Intake: Total (mg/kg/day)	Percent Due To Sediment Ingestion	Percent Due To Dermal Contact	Potential Threshold Effects: Acceptable Chronic Intake (mg/kg/day)	Hazard Index	Potential Cancer Risk: Carcinogenic Potency Factor (day-kg/mg)	Excess Lifetime Cancer Risk
Total PAH	3.45E-08	91.41%	8.59%	(a)	(a)	(b)	(b)
Pot. Carc. PAH (c)	1.22E-08	91.41%	8.59%	(a)	(a)	1.15E+01	1.40E-07
Arsenic	1.13E-08	100.00%	0.00%	(a)	(a)	1.50E+00	1.69E-08
Chromium (d)	1.13E-08	100.00%	0.00%	5.00E-03	2.25E-06	(b)	(b)
Copper	2.82E-08	100.00%	0.00%	3.70E-02	7.62E-07	(b)	(b)
Lead	1.13E-07	100.00%	0.00%	1.40E-03	8.05E-05	(b)	(b)
Zinc	6.54E-07	100.00%	0.00%	2.10E-01	3.11E-06	(b)	(b)
				Summed Index =	8.66E-05	Summed risk =	1.57E-07

(a): EPA has not derived an AIC for that compound.
(b): The compound is not assumed to be carcinogenic through the oral and dermal route.
(c): See Table 2-2 for the list of potentially carcinogenic PAH.
(d): The AIC for chromium VI was used in the table.

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2.3.4 Potential Health Risks from Hypothetical Future Groundwater Use

As discussed in Section 2.2.1.3, no PCOCs have been detected in the aquifer at the interval from 175 to 205 feet, and, consequently, no current risk exists from drinking waters from this aquifer. However, if migration of PCOCs with vertical and horizontal groundwater flow occurs in the future, potential intakes of PCOCs in drinking water could potentially occur via future hypothetical wells (see Situations 1, 2 and 3 depicted in Figure 2-1). As discussed in Section 2.2.6, quantitative evaluation of the intakes associated with these three PEPs was not possible. Consequently, although potential carcinogenic and noncarcinogenic risks associated with these three PEPs could potentially exist in the future, PCOCs were assumed, for the purposes of estimating a worst case exposure, to migrate to the points of exposure at concentrations equal to those observed during the Remedial Investigation in the 10 foot and 50 foot sands.

Estimates of the potential carcinogenic and non-carcinogenic health risks caused by potential exposure to maximum and minimum PCOC concentrations in the groundwater are presented in Tables 2-20A and 2-20B. The total estimated upper 95% bound excess lifetime cancer risk ranges from 5×10^{-2} to 4×10^{-3}. The hazard index for the maximum exposure scenario is 5.57, exceeding unity, thereby posing potential non-carcinogenic health effects. The hazard index for the minimum concentration exposure scenario is 0.13. This is very conservative because adsorption to soils will likely attenuate these concentrations. Therefore, the potential risks for potential exposures to groundwater would be no higher than 1×10^{-3} and most likely would be substantially less.

2.3.5 Summary of Potential Health Risks

A summary of potential non-carcinogenic adverse health risks as represented by the hazard index (HI) is presented in Table 2-21. HIs for potential chronic effects associated with exposure maximum PCOC concentrations are listed for utility workers, construction workers, commercial occupants, exposures to sediments, and for hypothetical future residents. Potential chronic effects associated with exposure to minimum PCOC concentrations were evaluated for those individuals potentially exposed to sediments. Each PCOC concentration is broken down by route of exposure: ingestion, dermal contact, and inhalation. None of the HIs evaluated for each PEP for either exposure scenario (maximum or minimum) exceed one, indicating that little or no potential exists for non-carcinogenic

Table 2-20A

POTENTIAL MAXIMUM HYPOTHETICAL GROUND-WATER RISKS

The hazard index for potential chronic effects and the 95% upper bound excess lifetime cancer risk is shown for a person hypothetically exposed to the maximum PCOC groundwater concentrations. PCOCs not listed were not detected.

			Potential Threshold Effects		Potential Cancer Risk	
PCOC	Maximum Concentration (mg/l)	Potential Daily Intake Total (mg/kg/day)	Acceptable Chronic Intake (mg/kg/day)	Hazard Index	Carcinogenic Potency Factor (day-kg/mg)	Excess Lifetime Cancer Risk
Total PAH	8.714	2.49E-01	(a)	(a)	(b)	(b)
Pot. Carc. PAH (c)	0.104	2.97E-03	(a)	(a)	1.15E+01	3.36E-02
Arsenic	0.522	1.49E-02	(a)	(a)	1.50E+00	2.21E-02
Chromium	0.45	1.29E-02	5.00E-03	2.57E+00	(b)	(b)
Copper	1.34	3.8[illegible]E-02	3.70E-02	1.03E+00	(b)	(b)
Zinc	1.18	3.37E-02	2.10E-01	1.61E-01	(b)	(b)
Benzene	0.93	2.66E-02	(a)	(a)	5.20E-02	1.38E-03
Ethylbenzene	0.48	1.37E-02	1.00E-01	1.37E-01	(b)	(b)
Toluene	1	2.86E-02	3.00E-01	9.52E-02	(b)	(b)
Xylene	1.1	3.14E-02	2.00E-02	1.57E+00	(b)	(b)
			Summed Index =	5.57E+00	Summed risk =	5.71E-02

(a): EPA has not derived an AIC for that compound.
(b): The compound is not considered to be carcinogenic through the oral route.
(c): See Table 2-2 for a list of potentially carcinogenic PAHs.

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Table 2-20B

POTENTIAL MINIMUM HYPOTHETICAL GROUND-WATER RISKS

The hazard index for potential chronic effects and the 95% lower bound excess lifetime cancer risk is shown for a person hypothetically exposed to minimum PCOC ground-water concentrations. PCOCs not listed were not detected.

PCOC	Minimum Concentration (mg/l)	Potential Daily Intake Total (mg/kg/day)	Potential Threshold Effects: Acceptable Chronic Intake (mg/kg/day)	Potential Threshold Effects: Hazard Index	Potential Cancer Risk: Carcinogenic Potency Factor (day-kg/mg)	Potential Cancer Risk: Excess Lifetime Cancer Risk
Total PAH	3.00E-02	8.57E-04	(a)	(a)	(b)	(b)
Pot. Carc. PAH (c)	1.00E-02	2.86E-04	(a)	(a)	1.15E+01	3.28E-03
Arsenic	5.00E-03	1.43E-04	(a)	(a)	1.50E+00	2.14E-04
Chromium	5.00E-03	1.43E-04	5.00E-03	2.86E-02	(b)	(b)
Copper	1.25E-01	3.57E-03	3.70E-02	9.65E-02	(b)	(b)
Zinc	1.00E-02	2.86E-04	2.10E-01	1.36E-03	(b)	(b)
Benzene	2.50E-03	7.14E-05	(a)	(a)	5.20E-02	3.71E-06
Ethylbenzene	2.50E-03	7.14E-05	1.00E-01	7.14E-04	(b)	(b)
Toluene	2.50E-03	7.14E-05	3.00E-01	2.38E-04	(b)	(b)
Xylene	2.50E-03	7.14E-05	2.00E-02	3.57E-03	(b)	(b)
			Summed Index =	1.31E-01	Summed risk =	3.50E-03

(a): EPA has not derived an AIC for that compound.
(b): The compound is not considered to be carcinogenic through the oral route.
(c): See Table 2-2 for a list of potentially carcinogenic PAHs.

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Table 2-21

SUMMARY OF POTENTIAL HAZARD INDICES

A summary of the hazard index for potential chronic effects is shown for each source area. The potential total HI and its breakdown by PEP is also shown.

	Utility Workers (b)	Construction Workers (b)	Commercial Occupants (b)	Older Child (sediments) (b)	Future (c) Residential Development	Future (c) Commercial Occupants	Groundwater (c)
Maximum Concentration							
Ingestion	2.28E-05	4.45E-04	1.35E-04	5.36E-03	6.17E-03	1.35E-04	5.57E+00
Dermal Contact	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	(a)
Inhalation	1.09E-06	2.14E-05	(a)	(a)	(a)	(a)	(a)
Total HI:	2.39E-05	4.66E-04	1.35E-04	5.36E-03	6.17E-03	1.35E-04	5.57E+00
Minimum Concentration							
Ingestion	(a)	(a)	(a)	8.66E-05	(a)	(a)	1.31E-01
Dermal Contact	(a)	(a)	(a)	0.00E+00	(a)	(a)	(a)
Inhalation	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Total HI:	(a)	(a)	(a)	8.66E-05	(a)	(a)	1.31E-01

(a): Risks were not calculated for this PEP.
(b): Current and future HI's are equal.
(c): This exposure scenario, and the HI's associated with it, are hypothetical.

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adverse health effects from ingesting soils or sediments, dermally contacting soils or sediments, or inhaling airborne particulates.

Table 2-22 presents a summary of potential carcinogenic risks associated with exposures to various media from the South Cavalcade Site. Utility workers, construction workers, commercial occupants, persons exposed to sediments, and hypothetical future residents are the receptors identified to be potentially exposed to maximum PCOC concentrations. The total excess lifetime cancer risks for utility workers was 2×10^{-7} and was 4×10^{-6} for construction workers. The total excess lifetime cancer risk for current commercial occupants is 1×10^{-6} and the future risks are 3×10^{-8}. The older-child-receptor group is predicted to have an excess lifetime cancer risk associated with exposure to sediments of 1×10^{-6}. Future hypothetical residential excess lifetime cancer risks are 1×10^{-5}. In all of these exposure scenarios, inadvertent ingestion of potentially contaminated soil contributes to the majority of the carcinogenic risk. These risks, based on conservative assumptions, are likely to overestimate any real risks experienced by each of the receptor groups assuming the two soil samples represent the true maximum concentration. If these samples do not, then the upper bound will be higher. Section 2.5 discusses the impact of such assumptions as well as other sources of uncertainty that may lead to overestimation and underestimation of adverse health risks.

2.4 Environmental Risk Assessment

2.4.1 Hazard Identification

A variety of PCOCs have been selected for assessment based on human health considerations (Table 2-1). These PCOCs, which have been found in surficial soils and sediments will also be considered for the environmental assessment.

2.4.2 Exposure Assessment

The South Cavalcade site is flat and much of it is vegetated. The central portion contains large open areas dominated by grasses and other herbaceous vegetation. The central portion of the site also contains smaller areas that are wooded. The site is surrounded by industrial facilities on three sides, a residential neighborhood on the other, busy roads to the north and south and railroad tracks to the east and west. Given this location, it is unlikely that the site serves as an important sanctuary for any threatened or endangered species,

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Table 2-22

SUMMARY OF POTENTIAL CARCINOGENIC RISKS

A summary of the 95% upper bound excess lifetime cancer risk for potential chronic effects is shown for each source area. The potential total risk and its breakdown by PEP is also shown.

	Utility Workers (b)	Construction Workers (b)	Commercial Occupants (b)	Older Child (sediments) (b)	Future (c) Residential Development	Future (c) Commercial Occupants	Groundwater (c)
Maximum Concentration							
Ingestion	1.93E-07	3.76E-06	1.18E-06	1.33E-06	1.23E-05	3.61E-07	5.71E-02
Dermal Contact	2.12E-09	3.97E-07	1.27E-07	7.10E-08	7.21E-07	3.52E-08	(a)
Inhalation	4.25E-09	1.80E-07	(a)	(a)	(a)	(a)	(a)
Total Risk:	2.23E-07	4.34E-06	1.18E-06	1.40E-06	1.30E-05	3.62E-07	5.71E-02
Minimum Concentration							
Ingestion	(a)	(a)	(a)	1.45E-07	(a)	(a)	3.29E-03
Dermal Contact	(a)	(a)	(a)	4.66E-08	(a)	(a)	(a)
Inhalation	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Total Risk:	(a)	(a)	(a)	1.57E-07	(a)	(a)	3.29E-03

(a): Risks were not calculated for this PEP.
(b): Current and future risks are equal.
(c): This exposure scenario, and the risks associated with it, are hypothetical. Risks are based on soil concentrations that have have been adjusted for degradation.

007725

however, it does provide habitat for more common plants, mammals, birds, invertebrates and reptiles. The site also contains and is bordered by drainage ditches. In the spring or after heavy rains, these contain water and may be inhabited by insects and amphibians that need only ephemeral sources of water.

Biota on the site may be exposed to PCOCs via three media:

- o Surface soils
- o Surface water
- o Sediments

Several PEPs exists. These include direct or indirect PEPs by which plants and wildlife on the site can be exposed to the PCOCs at the site. Direct PEPs include direct contact with a media such as surface soils or sediments. Indirect PEPS include foodchains, for example animals consuming other animals or plants that contain PCOCs or residues of PCOCs from the site.

007726

Surface Water and Sediments

The drainage ditches in the site and along its borders may serve as a habitat for some amphibians and aquatic insects that require ephemeral sources of water. Dermal absorption and ingestion would be the PEPs for these organisms. Some organisms would be exposed to the sediments to a greater degree. These include invertebrates living in or on the sediments for at least a portion of their life cycles. PAHs, arsenic, chromium, copper, lead and zinc have been found in sediment samples (Table 2-5).

Surficial Soils

PAHs, arsenic, chromium, copper, lead and zinc have been identified in at least one surficial soil sample (Table 2-4). Organisms living in or borrowing in the soil could be exposed via direct contact or ingestion. Other animals may also ingest some soils while consuming plants or rooting for soil invertebrates. Grooming and preening activities may also result in some inadvertent ingestion of soils.

Groundwater

Groundwater flow in the upper aquifer at the site flows to the west. One possible discharge point is the Little White Oak Bayou. If the Little White Oak Bayou is a discharge point, then aquatic organisms may potentially be exposed to PCOCs in the groundwaters. Presently, there is no evidenced that the PCOCs have reached the bayou.

Food Chain

Some PCOCs may be transmitted via the food chain. Some are more readily bioconcentrated and bioaccumulated than others. Organisms higher in the food chain may show adverse effects, due to higher body burdens of the PCOCs than at lower trophic levels.

2.4.3 Ecological Risk Assessment

The following is a qualitative discussion of the potential risks posed to the environment due to exposure to PCOCs at the Koppers South Cavalcade Site. Quantification is not justified or possible because biota have not been completely surveyed at the site and standards or criteria are not available for most exposure media.

It is not known to what extent wildlife are present at the site, however, as noted earlier in the environmental assessment the location of the site suggests that the site will have relatively few wildlife. Although the surface soils in two small areas of the site do appear to contain PCOCs, these are near the areas of human activity, within the fenced areas, and have less vegetative cover than other areas of the site. All of these factors suggest that these two small areas will not be visited regularly by wildlife, especially since the much larger and uncontaminated central area of the site has more attractive habitats. Thus, wildlife exposure to PCOCs would likely be infrequent, intermittent and at low levels.

Similarly, any organisms that use or live in the drainage ditches will also only be exposed infrequently and at low levels. An additional problem associated with potential PCOC exposures from the drainage ditches is the contribution of PCOCs by other sources on or surrounding the site. The drainage ditches in the central area of the site are the cleanest and those surrounding the perimeter on the site have the highest PCOC concentrations. The ditches surrounding the site receive runoff from the adjacent railroad tracks and roadways and also from some of the trucking companies using the site. All of these sources may potentially make significant contributions to the total PCOC load of the drainage ditches. Thus, only a fraction of the risks estimated for PCOCs in the drainage ditches may be due to past site related activities.

Although the possibility of adverse effects on any sensitive wildlife that may reside on the site cannot be precluded, this is considered very unlikely. The site is not likely to have wildlife on it for long periods of time and the areas having PCOCs to which wildlife may be exposed are relatively small and not as attractive as clean areas on the site.

2.5 Sources of Uncertainty

007728

The process of health risk assessment at national priority list hazardous waste sites involves four general steps:

1) identification and selection of PCOCs;
2) quantification of potential exposures;
3) evaluation of the potential toxicity of PCOCs; and
4) prediction of potential risk from these contaminants.

Within any of these steps, numerous assumptions must be made. Some of the assumptions have a substantive scientific basis, while others do not. Because we are not absolutely certain about any of the assumptions, some level of uncertainty is introduced into the risk assessment process each time an assumption is made. In this section, the assumptions that introduce the greatest amount of uncertainty, as well as their effect on the estimates of risk, are discussed. The discussion of their effect will be qualitative, because in most instances we do not yet have enough information to quantify the magnitude of those uncertainties. This section is divided into subsections that correspond to the four steps involved in the risk assessment process.

2.5.1 Hazard Identification and Selection of Potential Contaminants of Concern

In this step of a risk assessment, information on the types, concentrations, frequency of occurrence, and distribution of contaminants at the site is combined with measures of the potential toxicity of each of those contaminants to determine their potential risk. In determining the potential risk, uncertainty can be introduced in several places. Some of the more important sources of uncertainty are presented below.

Sampling Error

The sampling locations determined for the site may not identify all of the compounds on the site nor all contaminated areas nor the exact concentration of PCOCs in contaminated areas. At the South Cavalcade site, sampling error contributes significant uncertainty to the risk assessment. Only two data points were available, both from surficial soils. It is very difficult, if not impossible to accurately characterize the risk associated with a given media, based on only two samples. Furthermore, in the absence of data from surface soils, results from these two surficial soil samples were used to estimate exposures and risks from surface soils. The assessment assumes that all surface soils on the site have PCOC concentrations equal to this level. In reality, most of the surface soils show no evidence of visible contamination while a few areas are visibly contaminated. Because of limited sampling, the concentration of PCOCs in surface soils that are and are not visibly contaminated is not known. It is likely that actual PCOC concentrations in visibly clean soils are lower than the concentrations used in this risk assessment and that PCOC concentrations in visibly contaminated areas are higher than concentrations used in this risk assessment. A person contacting only clean soils could have lower risks than estimated in the assessment and a person visiting contaminated areas could have higher risks. In other media of concern, where more data are available, this source should make a smaller contribution to total uncertainty. Additionally, uncertainty is introduced because soils were not analyzed for volatile compounds. Thus actual risks to utility workers and construction workers could be somewhat greater than those reported in the risk assessment. 007729

Measurement Error

Numerous and complicated analyses, requiring a great deal of manipulation, are needed to identify and quantify the compounds present on a hazardous waste site. The quantity of compounds present on the site can be either underestimated or overestimated. On rare occasions, compounds may also be mis-identified.

Potential Toxicity

Initial evaluation of a compound is dependent, in part, upon the potential toxicity of the compound. Some compounds have not been investigated in sufficient detail to insure that all of their toxic properties or the severity of their potentially toxic effects are well quantified. It is likely, however, that the most potentially toxic compounds have been identified and that this source of uncertainty contributes little to the overall uncertainty of the risk assessment.

2.5.2 Estimation of Potential Exposure

During this step of a risk assessment, the concentration of each PCOC is either measured or estimated in various media with which human or environmental receptors will come into contact. In many cases, contaminant levels in media that may be contacted by a receptor cannot, or have not, been measured directly. In such cases concentrations need to be estimated or modeled. Estimates and models require assumptions and these lead to uncertainty. Once the concentration in a medium is known or has been predicted, human exposure and dose need to be estimated. These too, require assumptions that may lead to uncertainty. The more important sources of uncertainty are discussed below.

007730

Estimation of Soil Concentrations

At the South Cavalcade Site, information on the distribution and concentration of PCOCs in surface soils throughout the site was not available. No valid surface soil data was available and only two valid surficial soil samples were available. Both of these samples were from surficial depths (0.5 to 6 feet). For the exposure assessment, it was assumed that these two data points were representative of both surficial and surface soil throughout the site. Typically when limited information is available, a worst case exposure estimate is used. These almost always result in an overestimate of exposure and risk. The intent is to be conservative, erring on the side of public health. The estimates of risk developed in this risk assessment probably err on the side of public safety for most areas on the site but may not do so for some of the visibly contaminated surface soils.

Estimation of Sediment Concentration

Two exposures to sediments were developed: a maximum and minimum scenario. Sediment concentrations were estimated using the maximum and minimum PCOC concentrations measured in the South Cavalcade Site. The assumptions that were used for these two scenarios were identical and are likely to overestimate exposure and risk given that the sediments having measurable levels of PCOCs were in areas that are not easily accessible or attractive. Thus the risks estimated for the maximum scenarios should be viewed only as an extreme of potential exposure and risk. Most older children will have potential exposures that fall in between these two extremes and well below the maximum scenario. In order to provide some measure of central tendency for potential exposure to sediments, a third exposure scenario using the geometric mean of sediment PCOC concentrations could be devised. However, there were too few samples for a measure of central tendency to be approximated by a geometric mean. Any one person's exposure and risk will depend upon the sediments he or she may come into contact with, and this can only be assessed on a case-by-case basis. 007731

Source of PCOCs in Sediment

The risk assessment assumes that all of the PCOCs present in the sediment originated from past activities by the Koppers Company on the South Cavalcade Site. This is likely to be an invalid assumption. The contaminated sediments are located in an area that has several other potential sources of PAHs. The drainage ditch containing the sediments is located between railroad tracks and a trucking company on-site. The railroad tracks have been recently repaired and new ties put in place. It is possible that during rainstorms some of the PAHs from the freshly treated ties run off into the drainage ditch. During rainstorms it is also possible for the PAHs in lubrication and diesel oils used by the trucking company to run off into the drainage ditch. Finally, the site is located near a busy intersection that can also contribute to the PAH load in the drainage ditch. Thus, several potential sources of PAH to the drainage ditch exist. The risk assessment has not attempted to apportion the contribution of the different sources to the total exposure.

Degradation of Potential Contaminants of Concern

In some scenarios no account has been made for the natural degradation of PCOCs. Half-lives for some of the PCOCs have been published in the literature (EPA 1986; see also

Appendix 2-B for PAH half-lives used in future surface soil scenarios). Use of degradation rates would reduce the amount of PCOCs available for intake. Neglecting the degradation of PAHs in sediments, buried soils and groundwater leads to an overestimation of potential risks. This is especially true for potential chronic exposure over a 70 year time period. The PAH degradation rates used in this risk assessment for surface soils are based on a survey of rates from the literature (see Appendix 2-B). Review of the scientific literature indicates that many site specific parameters influence degradation of PAHs. Because of this, a degradation rate equal to the upper 95 percentile was chosen, and consequently, it is likely that degradation of PAHs has been underestimated. A mean degradation rate, based on a review of the literature would have been almost four times faster (Appendix 2-B).

<u>Frequency of Potential Exposure</u>

Once the concentration of PCOCs in water, soil, or air is known by either measurement or modeling, the amount of the PCOCs to which humans are potentially exposed must be estimated. This entails making assumptions concerning the frequency and extent of human exposure.

Some of the assumptions used to estimate frequency of exposure can be quite uncertain. For example, the frequency at which teenagers visit the South Cavalcade Site, and are thus exposed to PCOCs is unknown. The frequency at which children in the hypothetical future residential neighborhood ingest soil is also unknown.

In the absence of such data, assumptions need to be made to estimate exposure frequency. These depend upon the location, accessibility and use of the site. Since, in the hypothetical future worst case scenario, it is assumed that the site could become a residential neighborhood, a greater exposure frequency was used for children (half the days per year) than for adults (26 days per year). Because the northern and southern areas of the site are partially fenced, only older children, who may trespass onto the site, were assumed to be exposed. It is unlikely, but possible, that exposures will be more frequent than has been assumed. However, exposures could be much lower. If a hypothetical future resident of the site does not spend most of his of her time on site, then the individual's potential exposure would be reduced, and the health risks reported here would be an overestimate.

Assumptions regarding the number of hours a commercial occupant leaves an office building and goes outside is uncertain. The estimation of 1 hour per day for each day of a work week takes into account those employees whose jobs entail working at the office. All three commercial establishments are transport companies where the majority of the employees are truck drivers. Because of the nature of their occupation these employees are likely to be off-site a significant portion of their entire work day, and even possibly their work week. It is the conservative approach that 5 hours per week, or 20 days (at twelve hours per day) per year was used in this risk assessment.

Similarly, assumptions need to be made regarding the amount of soil people ingest and how much of their skin comes into contact with contaminated soil. Many of the assumptions used to estimate these parameters are based on experimental data, so uncertainty is reduced. It is always possible that people visiting a contaminated area have either higher or lower potential exposures and risks than have been assumed. In general, the assumptions used are thought to lead to an over- estimate of exposure rather than an underestimate for most, but not necessarily all, people.

007733

2.5.3 Dose-Response Assessment

Accepted practice divides potential health effects of concern at hazardous waste sites into two general categories: effects with a threshold, and effects without a threshold. Dose-response assessments for both of these types of effects share many of the same sources of uncertainty. In the discussion below, the more important sources are presented. Assumptions that are anticipated to create more uncertainty for one class of effects than the other are noted.

Animal-to-Human Extrapolation

For many compounds animal studies provide the only reliable information on which to base an estimate of adverse human health effects. Extrapolation from animals to humans introduces a great deal of uncertainty in the risk assessment. Some of this uncertainty can be reduced if a compound's fate and the mechanism by which it causes adverse effects is known in both animals and humans. When the fate and mechanism is unknown, uncertainty increases. The procedures used to extrapolate from animals to humans make conservative assumptions such that overestimation of effects in humans is far more likely than underestimation. Nevertheless, because the fate of compounds can differ in humans and animals, it is possible that animal experiments will not reveal an adverse effect that would manifest itself in humans. These can result in an underestimation of the effect in humans.

The opposite is also true; effects observed in animals may not be observed in humans, resulting in an overestimation. Thus, animal-to-human extrapolation can introduce a great deal of uncertainty: an overestimate of the adverse impacts on humans is likely, but an underestimation of the risks cannot be ruled out.

High-to-Low Dose Extrapolation

The concentration of compounds to which people are potentially exposed at hazardous waste sites is usually much lower than the levels used in the studies from which dose-response relationships are developed. Predicting effects at hazardous waste sites, therefore, requires use of models that allow extrapolation of effects from high to low doses. These models contain assumptions which introduce uncertainty and the uncertainty can be very large. Usually it is larger for potential carcinogens than for non-carcinogens. Typically, assumptions are chosen such that overestimation of risk is far more likely than underestimation; however, when the mechanism of action is unknown, there is a possibility that the potential for adverse effects can be underestimated. 007734

Compound-to-Compound Extrapolation

PAHs are a class of compounds that are potential human carcinogens. Information on carcinogenic potential is available for only few members of the PAH class. Potential carcinogenicity of all other members of this class is based on the above mentioned limited information. Therefore, the assumption is made that all potentially carcinogenic PAHs are as potentially carcinogenic as benzo(a)pyrene, the PAH assumed by the U.S. EPA to be most carcinogenic. ICF-Clement (1987) has recently developed a relative potency scheme for potentially carcinogenic PAHs that is under review by EPA and ATSDR. If the other PAHs are not as potentially carcinogenic as benzo(a)pyrene, then risks estimated in this risk assessment would be high and not representative of true risk. For example, chrysene is 227 times less potent than benzo(a)pyrene in the ICF relative potency scheme (ICF, 1987). Neither the U.S. EPA nor the ATSDR have, as yet, incorporated this new data and officially revised the carcinogenic potency factors for PAHs. The risk assessment also assumes that all the chromium identified in the various media is chromium VI. Chromium VI is more toxic than chromium III and it is likely that some portion of the chromium identified in the various media is chromium III. Therefore, the risks reported in this risk assessment overestimate risks from chromium. In the absence of information about chromium speciation and in order to be protective of the public health, the risk assessment assumed that all chromium on the site is as toxic as chromium VI.

2.5.4 Risk Characterization

Based on estimated levels of exposure and dose-response relationships, the risk of adverse human health effects is characterized. Two important additional sources of uncertainty are introduced in this phase of the risk assessment: the evaluation of potential exposure to multiple compounds and the presence of sensitive subpopulations.

Risk from Multiple Compounds

Once exposure to and risk from each of the compounds is quantified, the total risk posed by the site is determined by combining the health risk from each of the compounds. Presently, threshold effects are added, unless evidence exists indicating that the compounds being investigated interact synergistically (a response that is greater than expected) or antagonistically (a response that is smaller than expected) with each other. The same is true for potentially carcinogenic effects. For virtually all combinations of compounds at hazardous waste sites, little if any evidence on interaction is available. Therefore, additivity is assumed. The assumption of additivity adds uncertainty and, while the exact magnitude is unknown, it is not expected to be large. Whether assuming additivity leads to an underestimation or overestimation of risk is also unknown and will vary on a case-by-case basis.

Risk to Sensitive Populations

The health risks estimated in the risk characterization section generally are applicable to the average resident near the site. Human sensitivity varies from person to person. In some cases it is possible to identify sensitive populations that may be exposed to contaminants on the site and quantify a separate risk for that group. At other times it may not be possible to identify such groups. At South Cavalcade, children were identified as such a group. In all cases, some people will be more sensitive than the average person and, therefore, will be at greater risk. This source of uncertainty is difficult to quantify, but the underestimation of risk due to varying sensitivities is more than compensated for by the use of assumptions throughout the risk assessment that overestimate risk to the average person.

2.5.5 Summary of Sources of Uncertainty

The most important sources of uncertainty in this risk assessment appear to be: lack of surface soil data; selection of PCOCs to monitor in subsurface soils; selection of concentrations of PCOCs in soil; neglect in all scenarios of degradation of potential contaminants of concern over time; and, potential carcinogenicity of PAHs as a class. Assumptions were made in every case that could lead to potentially large overestimates of health risks. As discussed elsewhere in the report, any one person's potential exposure and risk are influenced by all the parameters mentioned in Section 2.5 and thus, must be estimated on a case-by-case basis.

007736

APPENDIX 2-A

ESTIMATION OF POTENTIAL INHALATION RISKS TO CONSTRUCTION WORKERS FROM VOLATILIZATION OF POTENTIALLY CARCINOGENIC PAH FROM SURFICIAL SOILS

007737

APPENDIX 2-A
ESTIMATION OF POTENTIAL INHALATION RISKS TO CONSTRUCTION WORKERS FROM VOLATILIZATION OF POTENTIALLY CARCINOGENIC PAH FROM SURFICIAL SOILS.

Potential risks associated with air concentrations of potentially carcinogenic PAH are derived in this appendix. The air concentrations are based upon one half of the maximum detection limit for potentially carcinogenic PAH in South Cavalcade surficial soils. The calculated air concentrations only consider volatilization and do not account for dispersion. Potential construction worker exposures were estimated based on the assumptions detailed in Table 2-6.

007738

Computation of Potentially Carcinogenic PAH Concentrations in Air Above Soil. A compound in soil may be partitioned between the soil water, soil air, and the soil constituents. The three main transport processes for a compound in soil to enter the atmosphere are:

- o compound in soil to compound in solution.
- o compound in solution to compound in vapor phase in soil air.
- o compound in vapor phase in soil air to compound in atmosphere (Lyman et al 1982).

A compound may adhere strongly to dry soil, reducing its volatilization rate, but when soil is wetted the stronger affinity of the water displaces the compound allowing volatilization to occur at a faster rate. However, if the concentration of a compound in soil becomes high enough so that its chemical activity approaches that of a pure compound, the presence or absence of water will not affect its volatilization (Lyman et al 1982). A pure compound can volatilize directly into a vapor. This calculation assumes that no pure compound exists.

The partitioning of the compound between soil and water is determined by the partition coefficient, K_{oc}, and fraction of organic carbon, f_{oc}, as shown by the following equation (Mills et al 1985):

$$\frac{\text{concentration in soil}}{\text{concentration in soil water}} = K_{oc} f_{oc} \qquad (1)$$

The partitioning of the compound between soil water and soil air is determined by Henry's Constant, K_H, as shown by the following equation (Mills et al 1985):

$$\frac{\text{concentration in soil air}}{\text{concentration in soil water}} = 41.6\,K_H \;(\text{atm-m}^3/\text{mole}),\ \text{at } 20^{o}\text{C} \qquad (2)$$

The concentration of a compound in soil air can thus be calculated for a given concentration of the compound in soil by combining equations 1 and 2.

$$\frac{\text{concentration in soil air}}{\text{concentration in soil}} = \frac{41.6\,K_H}{K_{oc}\,f_{oc}} \qquad (3)$$

Table 2-A-1 shows the concentration in the soil air calculated for potentially carcinogenic PAHs in South Cavalcade surficial soils. The concentrations of potentially carcinogenic PAH in the soil air surrounding the soil containing the PAH are very low (Table 2-A-1). Summing the concentration of each individual PAH results in a total potentially carcinogenic PAH concentration of 3.15×10^{-6}(mg/m^3). The concentration of potentially carcinogenic PAH in the atmosphere above the soil cannot exceed this concentration.

Potential Risks Associated with Estimated PAH Concentrations in Air. Assuming that a construction worker breathes 16 cubic meters of soil air per day, that he or she is on-site for 195 days per year and one year per lifetime, that the construction worker weighs 70 kilograms, and that all potentially carcinogenic PAH are as potent as benzo(a)pyrene, his or her potential excess lifetime cancer risk is 6.32×10^{-8}. True risks will likely be orders of magnitude lower than this value because true air concentrations will be orders of magnitude lower. Some of the mechanisms that have not been accounted for in this analysis and that would result in lower atmospheric concentrations are listed below.

1. The soil containing the PAHs may be dry part of the time, causing a decrease in the rate of volatilization. If there is no soil water, the PAHs cannot dissolve and then volatilize into the air.

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2. A cycling rate of the air above the soil will dilute the atmospheric concentration because fresh air, air not containing PAHs from the site, will continually be introduced into the area above the site.

007740

Table 2-A-1

CALCULATION OF POTENTIALLY CARCINOGENIC PAH IN AIR DUE TO VOLATILIZATION

Shown are the conentrations of PCOCs in soil vapor. Concentrations were calculated only for potentially carcinogenic PAH in South Cavalcade subsurface soils.

PCOC	SOIL CONCENTRATION (ppb)	$K_{oc}FG_{oc}$ (a)	K_Hx41.6 (a)	AIR CONCENTRATION (ppb)	AIR CONCENTRATION (mg/m^3)(b)
Benzo(a)anthracene	5.80E+03	2.00E+03	4.16E-05	2.00E-05	1.16E-06
Benzo(a)pyrene	5.80E+03	5.50E+04	2.94E-05	1.70E-07	2.10E-08
Benzo(b)fluoranthene	--	5.50E+03	5.62E-04	8.50E-05	--
Chrysene	5.80E+03	2.00E+03	4.37E-05	2.20E-05	2.03E-06
Total Potentially Carc. PAH					3.15E-06

(a) Taken from: Mabey, W.R, J.H. Smith, R.T. Podoll, H.L. Johnson, T. Mill, T.W. Chow, J. Gates, I.W. Partridge, H. Juber, and D. Vandenberg. 1982. Aquatic Fate Process Data for Organic Priority Pollutants. EPA Rept. No. 44/4-81-014.

(b) Conversion factors were taken from: Verschueren, K. 1983. Handbook of Environmental Data on Organic Chemicals (second edition). Van Norstrand Reinhold Co., New York.

2-A-3a

007741

APPENDIX 2-B

ESTIMATION OF AVERAGE PAH CONCENTRATION IN SOUTH CAVALCADE SURFACE SOILS FOR THE NEXT 20 YEARS FOR COMMERCIAL OCCUPANTS AND NEXT 70 YEARS FOR HYPOTHETICAL RESIDENTS

007742

APPENDIX 2-B

ESTIMATION OF AVERAGE PAH CONCENTRATION IN SOUTH CAVALCADE SURFACE SOILS FOR THE NEXT 20 YEARS FOR COMMERCIAL OCCUPANTS AND NEXT 70 YEARS FOR HYPOTHETICAL RESIDENTS.

The future scenarios at South Cavalcade assume that PAHs in the surface soil degrade. Thus, potential exposure of potential receptors will decrease with time. The following steps were performed to estimate the average concentration of PAHs in South Cavalcade surface soils for the future exposure scenario, i.e. the next 20 years and 70 years.

1. The concentrations of total PAH and potentially carcinogenic PAH in South Cavalcade surface soils presented in Table 2-4 of Section 2 were used to estimate the 20 and 70 year average concentrations.

2. The upper 95 percentile of half-lives reported in the literature for benzo(a)pyrene was used in this risk assessment. This value was equal to 1385 days (see Appendix 2-C). The half-life of benzo(a)pyrene was assumed to be representative of other PAHs.

3. Annual decay of PAHs was calculated using the following formula:

   $$C_t = C_o \ e^{-kt}$$

   In this expression, C_t is equal to PCOC concentration at the time specified by the subscript, t is equal to the time period during which the PCOC is decaying, and k is equal to the first order degradation rate of the PCOC (k = .693/half life).

4. The concentration at the end of each year of a 20 year period was calculated for commercial occupants during their working career. The concentration at the end of each year of the 70 year period was also calculated for the hypothetical residential scenario.

5. The average soil concentration for the 20 year period was then derived by summing the concentration at the end of each year and dividing by 20, the total number of years. The average soil concentration for the 70 year period is tabulated the same way, dividing by 70 instead of 20.

Initial concentrations, concentrations at the end of each of the years, and the average concentration for total PAH and for potentially carcinogenic PAH for the 20 year period are shown in Tables B-1 and B-2. Tables B-3 and B-4 contain similar concentrations for the 70 year period.

007744

TABLE B-1

DETERMINING AVERAGE CONCENTRATIONS OVER A 20 YEAR PERIOD FOR TOTAL PAHs IN SOUTH CAVALCADE SURFACE SOILS

COMPOUND	INITIAL CONC.	HALF-LIFE	TIME (YEARS)	CONC. AT TIME T
TOTAL PAH (mg/kg)	87	3.8	0	87
	87	3.8	1	72.4966
	87	3.8	2	60.4110
	87	3.8	3	50.3401
	87	3.8	4	41.9482
	87	3.8	5	34.9552
	87	3.8	6	29.1279
	87	3.8	7	24.2721
	87	3.8	8	20.2258
	87	3.8	9	16.8541
	87	3.8	10	14.0444
	87	3.8	11	11.7031
	87	3.8	12	9.7521
	87	3.8	13	8.1264
	87	3.8	14	6.7717
	87	3.8	15	5.6428
	87	3.8	16	4.7021
	87	3.8	17	3.9182
	87	3.8	18	3.2651
	87	3.8	19	2.7208
	87	3.8	20	2.2672
			AVERAGE:	24.3117

007745

TABLE B-2

DETERMINING AVERAGE CONCENTRATIONS CVER A 20 YEAR PERIOD
FOR POTENTIALLY CARCINOGENIC PAHs IN SOUTH CAVALCADE SURFACE SOILS

COMPOUND	INITIAL CONC.	HALF-LIFE	TIME (YEARS)	CONC. AT TIME T
POT.	29	3.8	0	29
CARCIN.	29	3.8	1	24.1655
PAH	29	3.8	2	20.1370
(mg/kg)	29	3.8	3	16.7800
	29	3.8	4	13.9827
	29	3.8	5	11.6517
	29	3.8	6	9.7093
	29	3.8	7	8.0907
	29	3.8	8	6.7419
	29	3.8	9	5.6180
	29	3.8	10	4.6815
	29	3.8	11	3.9010
	29	3.8	12	3.2507
	29	3.8	13	2.7088
	29	3.8	14	2.2572
	29	3.8	15	1.8809
	29	3.8	16	1.5674
	29	3.8	17	1.3061
	29	3.8	18	1.0884
	29	3.8	19	0.9069
	29	3.8	20	0.7557
			AVERAGE:	8.1039

007746

TABLE B-3

DETERMINING AVERAGE CONCENTRATIONS OVER A 70 YEAR PERIOD FOR TOTAL PAHs IN SOUTH CAVALCADE SURFACE SOILS

COMPOUND	INITIAL CONC.	HALF-LIFE	TIME (YEARS)	CONC. AT TIME T
TOTAL PAH (mg/kg)	87	3.8	0	87.0000
	87	3.8	1	72.4966
	87	3.8	2	60.4110
	87	3.8	3	50.3401
	87	3.8	4	41.9482
	87	3.8	5	34.9552
	87	3.8	6	29.1279
	87	3.8	7	24.2721
	87	3.8	8	20.2258
	87	3.8	9	16.8541
	87	3.8	10	14.0444
	87	3.8	11	11.7031
	87	3.8	12	9.7521
	87	3.8	13	8.1264
	87	3.8	14	6.7717
	87	3.8	15	5.6428
	87	3.8	16	4.7021
	87	3.8	17	3.9182
	87	3.8	18	3.2651
	87	3.8	19	2.7208
	87	3.8	20	2.2672
	87	3.8	21	1.8892
	87	3.8	22	1.5743
	87	3.8	23	1.3118
	87	3.8	24	1.0932
	87	3.8	25	0.9109
	87	3.8	26	0.7591
	87	3.8	27	0.6325
	87	3.8	28	0.5271
	87	3.8	29	0.4392
	87	3.8	30	0.3660
	87	3.8	31	0.3050
	87	3.8	32	0.2541
	87	3.8	33	0.2118
	87	3.8	34	0.1765
	87	3.8	35	0.1470
	87	3.8	36	0.1225
	87	3.8	37	0.1021
	87	3.8	38	0.0851
	87	3.8	39	0.0709
	87	3.8	40	0.0591
	87	3.8	41	0.0492
	87	3.8	42	0.0410
	87	3.8	43	0.0342
	87	3.8	44	0.0285
	87	3.8	45	0.0237
	87	3.8	46	0.0198

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TABLE B-3

DETERMINING AVERAGE CONCENTRATIONS OVER A 70 YEAR PERIOD FOR TOTAL PAHs IN SOUTH CAVALCADE SURFACE SOILS

COMPOUND	INITIAL CONC.	HALF-LIFE	TIME (YEARS)	CONC. AT TIME T
	87	3.8	47	0.0165
	87	3.8	48	0.0137
	87	3.8	49	0.0114
	87	3.8	50	0.0095
	87	3.8	51	0.0079
	87	3.8	52	0.0066
	87	3.8	53	0.0055
	87	3.8	54	0.0046
	87	3.8	55	0.0038
	87	3.8	56	0.0032
	87	3.8	57	0.0027
	87	3.8	58	0.0022
	87	3.8	59	0.0018
	87	3.8	60	0.0015
	87	3.8	61	0.0013
	87	3.8	62	0.0011
	87	3.8	63	0.0009
	87	3.8	64	0.0007
	87	3.8	65	0.0006
	87	3.8	66	0.0005
	87	3.8	67	0.0004
	87	3.8	68	0.0004
	87	3.8	69	0.0003
	87	3.8	70	0.0002
			AVERAGE:	7.3504

007748

TABLE B-4

DETERMINING AVERAGE CONCENTRATIONS OVER A 70 YEAR PERIOD FOR POTENTIALLY CARCINOGENIC PAHs IN SOUTH CAVALCADE SURFACE SOILS

COMPOUND	INITIAL CONC.	HALF-LIFE	TIME (YEARS)	CONC. AT TIME T
POT. CARCIN. PAH (mg/kg)	29	3.8	0	29
	29	3.8	1	24.1655
	29	3.8	2	20.1370
	29	3.8	3	16.7800
	29	3.8	4	13.9827
	29	3.8	5	11.6517
	29	3.8	6	9.7093
	29	3.8	7	8.0907
	29	3.8	8	6.7419
	29	3.8	9	5.6180
	29	3.8	10	4.6815
	29	3.8	11	3.9010
	29	3.8	12	3.2507
	29	3.8	13	2.7088
	29	3.8	14	2.2572
	29	3.8	15	1.8809
	29	3.8	16	1.5674
	29	3.8	17	1.3061
	29	3.8	18	1.0884
	29	3.8	19	0.9069
	29	3.8	20	0.7557
	29	3.8	21	0.6297
	29	3.8	22	0.5248
	29	3.8	23	0.4373
	29	3.8	24	0.3644
	29	3.8	25	0.3036
	29	3.8	26	0.2530
	29	3.8	27	0.2108
	29	3.8	28	0.1757
	29	3.8	29	0.1464
	29	3.8	30	0.1220
	29	3.8	31	0.1017
	29	3.8	32	0.0847
	29	3.8	33	0.0706
	29	3.8	34	0.0588
	29	3.8	35	0.0490
	29	3.8	36	0.0408
	29	3.8	37	0.0340
	29	3.8	38	0.0284
	29	3.8	39	0.0236
	29	3.8	40	0.0197
	29	3.8	41	0.0164
	29	3.8	42	0.0137
	29	3.8	43	0.0114
	29	3.8	44	0.0095
	29	3.8	45	0.0079
	29	3.8	46	0.0066

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TABLE B-4

DETERMINING AVERAGE CONCENTRATIONS OVER A 70 YEAR PERIOD FOR POTENTIALLY CARCINOGENIC PAHs IN SOUTH CAVALCADE SURFACE SOILS

COMPOUND	INITIAL CONC.	HALF-LIFE	TIME (YEARS)	CONC. AT TIME T
	29	3.8	47	0.0055
	29	3.8	48	0.0046
	29	3.8	49	0.0038
	29	3.8	50	0.0032
	29	3.8	51	0.0026
	29	3.8	52	0.0022
	29	3.8	53	0.0018
	29	3.8	54	0.0015
	29	3.8	55	0.0013
	29	3.8	56	0.0011
	29	3.8	57	0.0009
	29	3.8	58	0.0007
	29	3.8	59	0.0006
	29	3.8	60	0.0005
	29	3.8	61	0.0004
	29	3.8	62	0.0004
	29	3.8	63	0.0003
	29	3.8	64	0.0002
	29	3.8	65	0.0002
	29	3.8	66	0.0002
	29	3.8	67	0.0001
	29	3.8	68	0.0001
	29	3.8	69	0.0001
	29	3.8	70	0.0001
			AVERAGE:	2.4501

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APPENDIX 2-C

ESTIMATION OF HALF-LIFE FOR BENZO(A)PYRENE IN SURFACE SOILS

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APPENDIX 2-C
ESTIMATION OF HALF-LIFE FOR BENZO(A)PYRENE IN SURFACE SOILS

The U.S. EPA has reported a half-life of 480 days for benzo(a)pyrene B(a)P in soils (EPA 1986a). Because this value is not supported by a citation from the scientific literature, the literature was reviewed in order to develop a more reliable estimate of the degradation of B(a)P in surface soils. [All PAHs are assumed to degrade at a rate equal to B(a)P.]

Table C-1 lists the half-lives found in the literature that may be of relevance to the conditions found at South Cavalcade. The half-lifes ranged from 1.0 days to 1957 days, with a mean of 375 days and standard deviation of 614 days. [The mean was calculated by using 15 days of the range reported by Shilina et al (1980).]

To be protective of the public health, a half-life of 1385 days was selected. This half-life represents a value below which 95% of half-lives are expected to fall, assuming that the values reported in the literature are representative of the real world. Ninety-five percent of all values in a normal distribution are expected to fall below the mean plus 1.645 standard deviations. Thus, the upper 95th percentile of half-lives was calculated by adding 1.645 standard deviations (614 days) to the mean (375 days).

The half-lives reported in the literature varied a great deal, probably because many site-specific factors can influence the rate at which B(a)P degrades. Thus, the value used in this risk assessment should not be interpreted as necessarily representative of soils in Houston or any other part of the United States. More detailed analysis of the factors influencing degradation is needed to derive site-specific values. Of special note is the apparent relatively rapid degradation of B(a)P in soils that have contained oil and PAHs for a long time compared to soils to which B(a)P has only recently been added. This indicates that acclimation of the microbiological community in the soil to the presence of PAHs may be necessary for rapid degradation. If true, the PAHs in South Cavalcade surface soils, which have contained PAHs for many years, may degrade faster than the rates assumed in this risk assessment.

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TABLE C-1
SUMMARY OF HALF-LIVES OF BENZO(A)PYRENE REPORTED IN THE LITERATURE

Half-Life (days)	References
1957	(a)
530	(b)
290	(b)
220	(b)
57	(c)
147	(d)
85.6	(d)
76.2	(d)
10.15	(e)

(a) Bossert, I.D. and R. Bartha (1986). Structure-biodegradability relationship of polycyclic aromatic hydrocarbons in soil. Bull. Env. Contam. Tox., 37:490-495.

(b) Cooker, M.P. and R.C. Sims (1987). The effect of temperature on polycyclic aromatic hydrocarbon persistence in an unacclimated agricultural soil. Haz. Waste Haz. Mat., 4:69-82.

(c) Groenewegen, D. and H. Stolp (1976). Microbial breakdown of polyaromatic hydrocarbons. Zbl. Bakt. Hyg. I. Abt: Orig., B162: 225-232.

(d) Khesina, A. Ya., M.P. Shcherback, L.M. Shabad, and I.S. Vostrov (1969). Benzpyrene breakdown by the soil microflora. Byulleten Ekxperimental' noi Biologii i Meditsiny., 68:70 As cited in Sims and Overcash (1983). Fate of polynuclear aromatic compounds (PNAs) in soil-plant systems. Residue Reviews, 88:1-68.

(e) Shilina, A.I., L.V. Vaneeva and A.V. Zhuravleva (1980). Benzo(a)pyrene persistence in the soil when it is introduced with soil dust particles. Migr. Zagryaz. Vesh. Poch. Supred. Sredaleh, Tr. Vses, Soves., 2nd Bobvnikova, Malakhovs, eds. pp. 100-105 CA95:198765.

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3.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

3.1 Introduction

Requirements under CERCLA (Section 121(d)), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) state that remedial actions must comply with applicable or relevant and appropriate requirements (ARARs) of Federal laws and more stringent, promulgated State laws.

A requirement may be either "applicable" or "relevant and appropriate" to a remedial action, but not both. Applicable requirements are cleanup standards, criteria, or requirements under Federal or promulgated State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site. Relevant and appropriate requirements may not be "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstanc at a CERCLA site, but they do address problems or situations sufficiently similar to those encountered at the CERCLA site is such that their use is well suited to the particular site.

Even though there are several types of ARARs, they can, for clarification, be divided into three separate groups: chemical-specific, location-specific, and action-specific.

Chemical-specific ARARs are requirements which set health or risk-based concentration limits or ranges for specific hazardous substances, pollutants, or contaminants. Maximum Contaminant Levels (MCLs) and National Air Quality Standards are examples of chemical-specific ARARs.

Location-specific ARARs set restrictions on activities based upon the characteristics of the site and/or the nearby areas. Examples of this type of ARAR include Federal and State siting laws for hazardous waste facilities and sites on the National Register of Historic Places.

The third classification of ARARs, action-specific, refers to the requirements that set controls or restrictions on particular activities related to the management of hazardous substances, pollutants, or contaminants. RCRA regulations for closure of hazardous waste storage units, RCRA incineration standards, and pretreatment standards under the Clean Water Act for discharges to POTWs are examples of action-specific ARARs.

Actual ARARs can be identified only on a site-specific basis. They depend on the detected chemicals at a site, specific site characteristics, and particular remedial actions proposed for the site. ARARs identified for the South Cavalcade site are discussed below.

3.2 Chemical-Specific ARARs

As previously stated, chemical-specific ARARs set health- or risk-based concentration limits or ranges for specific hazardous substances, pollutants, and/or contaminants. Tables 3-1A and 3-1B present a review of the potential Federal and State chemical-specific ARARs. The potential contaminants of concern (PCOCs) identified in the RI for the South Cavalcade site include: arsenic, benzene, potentially carcinogenic PAHs,[1] total PAHs, chromium VI, copper, ethylbenzene, toluene, total xylenes and zinc. Chemical-specific ARARs relevant to the South Cavalcade site are discussed below according to water quality and air quality standards.

1. Maximum Contaminant Levels for Drinking Water

The Federal Safe Drinking Water Act provides for the establishment of drinking water standards for public water systems. These standards are "applicable" only to public water systems as defined by the Act and regulations. However, they may be considered "relevant and appropriate" as ARARs for potential groundwater exposure via drinking water [U.S. EPA, Superfund Public Health Evaluation Manual (Oct. 1986)]. Although the upper aquifer on-site is not used as a drinking water source, the groundwater may migrate to lower aquifers which are used through the numerous wells in the area. Therefore, drinking water standards are considered ARARs for Remediation Alternatives.

1 Potentially carcinogenic PAHs include benzo(a)anthracene, chrysene, benzo(b)flouranthene, benzo(a)pyrene, dibenzo(a,h) anthracene, and indeno(1,2,3-cd) pyrene.

TABLE 3-1A

FEDERAL CHEMICAL-SPECIFIC ARARs

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant and Appropriate	Comment
Safe Drinking Water Act	40 U.S.C. 300			
National Primary Drinking Water Standards	40 C.F.R. Part 141	Establishes health-based standards for public water systems (maximum contaminant levels).	No/Yes	The MCLs for organic contaminants are relevant and appropriate for groundwater.
National Secondary Drinking Water Standards	40 C.F.R. Part 143	Establishes welfare-based standards for public water systems (secondary maximum contaminant levels).	No/Yes	Secondary MCLs for inorganic contaminants are relevant and appropriate for groundwater.
Maximum Contaminant Level Goals	Pub. L. No. 99-339, 100 Stat. 642 (1986)	Establishes drinking water quality goals set at levels of no known or anticipated adverse health effects with an adequate margin of safety.	No/No	Proposed MCLGs for organic contaminants should be treated as "other criteria, advisories and guidance".
Clean Water Act	33 U.S.C. 1251-1376			
Water Quality Criteria	40 C.F.R. Part 131 Quality Criteria for Water, 1976, 1980, 1986	Sets criteria for water quality based on toxicity to aquatic organisms and human health	No/Yes	AWQCs for PAHs, benzene, and metals are most likely to be relevant and appropriate for surface water discharges.
Toxic Pollutant Effluent Standards	40 C.F.R. Part 129	Establishes effluent standards or prohibitions for certain toxic pollutants: aldrin/dieldrin, DDT, endrin, toxaphen, benzidine, PCBs	No/No	Pollutants were not detected in groundwater samples.

TABLE 3-1A (continued)

FEDERAL CHEMICAL-SPECIFIC ARARs

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant and Appropriate	Comment
Solid Waste Disposal Act	42 U.S.C. 6901-6987			
Identification and Listing of Hazardous Waste	40 C.F.R. Part 264.1	Defines those solid waste which are subject to regulation as hazardous wastes under 40 C.F.R. Parts 262-265 and Parts 124,270, 271.	No/Yes	No contaminants on site are regulated under 40 CFR Parts 262-265, 270 and 271, however on-site contaminants are similar to those regulated.
Releases from Solid Waste Waste Management Units	40 C.F.R. Part 264 Subpart F	Establishes maximum contaminant concentrations that can be released from hazardous waste units in Part 264, Subpart F.	No/Yes	No solid waste management units on site, but may be contemplated.

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TABLE 3-1B

STATE CHEMICAL-SPECIFIC ARARs

Standard, Requirement, Criteria, or Limitation	State Agency	Description	Applicable/ Relevant and Appropriate	Comment
<u>Chemical Specific</u>				
Allowable Limits of Metals in Drinking Water	Dept. of Health	Establishes health-based standards for public water systems.	No/Yes	Identical to the Federal primary and secondary limits for metals.
Water Quality Standards for Surface Waters	Water Commission	Sets criteria for water quality based on toxicity to aquatic organisms and human health.	Yes/Yes	Criteria for toxicants were promulgated April 1988.
Prohibition of Air Contaminants which Adversely Effect Human Health and the Environment	Air Control Board	General restriction which is interpreted by the State to require compliance with occupational health limits.	Yes/No	Criteria are generally the same as OSHA requirements.
Control of Air Pollution from Visible Emissions and Particulate Matter	Air Control Board	Sets maximum allowable levels of particulates in air.	Yes/No	Criteria are ARARs only if an incineration option is selected as a remedy.
Sulfur, Fluoride, and Beryllium Compounds in Air	Air Control Board	Sets maximum allowable emissions for these compounds.	No/No	These compounds are not found on site.

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The primary "maximum contaminant levels" or "MCLs" for organic chemicals are considered ARARs (CERCLA Directive 9234.0-05). Primary MCLs are enforceable standards establishing maximum permissible levels of contaminants in drinking water. See 40 CFR14.2 (1986). These standards are health-based, but have treatability and economic components. See 42 USC 1401(1)(C). Primary MCLs are currently set for the following organic chemicals, in addition to pesticides and trihalomethanes: trichloroethylene, carbon tetrachloride, vinyl chloride, 1,2-dichloroethane, benzene, 1,1-dichloroethylene, 1,1,1-trichloroethane, and p-dichlorobenzene [40 CFR 141.61(a)].

The Safe Drinking Water Act also provides for establishment of secondary MCLs. These are designed to "control contaminants in drinking water that primarily affect the aesthetic qualities relating to public acceptance of drinking water" [40 CFR 143.1 (1986)]. The regulations noted that secondary MCLs "in the judgment of the Administrator (of EPA) are requisite to protect the public welfare" [40 CFR 143.2 (f)]. Federal secondary MCLs are set for chloride, color, copper, corrosivity, fluoride, foaming agents, iron, manganese, odor, pH, sulfate, total dissolved solids, and zinc (40 CFR 143.3).

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2. Federal Ambient Water Quality Criteria

Section 304(a) of the Clean Water Act, 33 USC 1314(a) (1982), requires EPA to develop water quality criteria related to protection of human health and aquatic life. EPA has developed criteria for numerous substances. The Federal water quality criteria are not legally enforceable and are therefore not "applicable" to the cleanup. However, since they do set levels which prevent toxicity and the Texas Water Quality Standards require prevention of toxicity, they may be considered "relevant and appropriate."

Under Section 121(d)(2)(A) of SARA, the remedy selected must "require a level or standard of control which at least attains . . . water quality criteria established under Section 304 or 303 of the Clean Water Act, where . . . such criteria are relevant and appropriate under the circumstances of time release or threatened release." SARA further provides that "in determining whether or not any water quality criteria under the Clean Water Act is relevant and appropriate under the circumstances of the releases, (EPA) shall consider the designated or potential use of the surface or groundwater, the environmental media affected, the purposes for which such criteria were developed, and the latest information available" [Section 121(d)(2)(B)(i) of SARA].

The ambient water quality criteria for acute and chronic toxicity to fresh water aquatic life for benzene and polynuclear aromatic hydrocarbons are relevant and appropriate for any discharge from the site to nearby surface water. This determination is based on the following considerations:

a. Existing or Potential Uses

The State of Texas has classified the nearby surface water (Hunting Bayou) for uses including navigation and industrial water supply. Although these uses do not include protection of aquatic life, the Texas Water Quality Standards also require all streams to be free of toxicity. The Federal water quality criteria for freshwater aquatic life are consistent with this use classification.

b. Environmental Medial Affected

Based on the findings of the Remedial Investigation Report, the environmental media potentially affected by the releases from treatment of contaminated groundwater include surface waters of Hunting Bayou Tributary near Legion Street.

c. Purposes of the Criteria

The water quality criteria were developed to protect freshwater organisms and their uses. These criteria are based on an evaluation of toxicity studies relating to species similar to those which are or could be present in Hunting Bayou.

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d. Latest Information Available

The EPA criteria documents are the latest information available and were used to develop the Federal water quality criteria for PAHs and benzene.

3. State Water Quality and Drinking Water Standards

In 1988, the Texas Water Commission promulgated criteria for specific toxic materials for protection of fresh water and marine aquatic life. These criteria are listed in Table 3-2. They are applicable requirements. The Texas Department of Public Health drinking water standards require the same maximum concentrations as do the Federal standards. The Texas drinking water standards are relevant and appropriate, and are listed in Table 3-3.

4. Federal Air Quality

National ambient air quality standards (NAAQS) are Federal ARARs established for air quality. Specifically, NAAQS have not been established for the potential contaminants of concern associated with the South Cavalcade site.

5. State Clean Air Act

Regulation I (31 TAC Chapter 111), "Control of Air Pollution from visible Emissions and Particulate Matter," Section 111.21, requires an opacity of 20 percent averaged over a five minute period. Section 111.52, "Ground Level Concentrations," requires that particulate matter from multiple sources, operated on contiguous properties, must not exceed any of the following net ground level concentrations: (1) 100 micrograms per cubic meter over any 5 consecutive hours; (2) 200 micrograms per cubic meter over any 3 consecutive hours; (3) 400 micrograms per cubic meter over any 1 hour period.

The Texas Clean Air Act (Section 401) also provides that "no person may cause, suffer, allow or permit the emission of air contaminants or the performance of any activity which causes or contributes to, or which will cause

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TABLE 3-2

STATE ARARs

STATE OF TEXAS ARARs PROPOSED WATER QUALITY CRITERIA FOR SPECIFIC TOXIC MATERIALS

(All values are listed or calculated in micrograms per liter.)

Parameter	Fresh Acute Criteria	Fresh Chronic Criteria
Aldrin	3.0	-
Arsenic	360	190
Cadmium	(1.128[1n(hardness)]-1.6672)	(0.7852[1n(hardness)]-3.490)
Chlordane	2.4	0.0043
Chlorpyrifos	0.083	0.041
Chromium (Tri)	(0.8190[1n(hardness)]+3.688)	(0.8190[1n(hardness)]-1.561)
Chromium (Hex)	16	11
Copper	(0.9422[1n(hardness)]-1.3844)	(0.8545[1n(hardness)]-1.386)
Cyanide	45.78	10.69
DDT	1.1	0.0010
Demeton	-	0.1
Dieldrin	2.5	0.0019
Endosulfan	0.22	0.056
Endrin	0.18	0.0023
Guthion	-	0.01
Heptachlor	0.52	0.0038
Hexachlorocycloehexane (Lindane)	2.0	0.08
Lead	(1.273[1n(hardness)]-1.460)	(1.273[1n(hardness)]-4.705)
Malathion	-	0.01
Mercury	2.4	0.012
Methoxychlor	-	0.03
Mirex	-	0.001
Nickel	(0.8460[1n(hardness)]+3.3612)	(0.8460[1n(hardness)+1.1645)
Total PCBs	2.0	0.014
Parathion	0.065	0.013
Pentachlorophenol	[1.005(pH)-4.830]	[1.005(pH)-5.290]
Selenium	260	35
Silver	[1.72[1n(hardness)]-6.52)	0.49
Toxaphene	0.78	0.0002
Zinc	(0.8473[1n(hardness)]+0.8604)	(0.8473[1n(hardness)]+0.7614

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TABLE 3-3

TEXAS DEPARTMENT OF HEALTH ALLOWABLE LIMITS OF METALS IN DRINKING WATER

Parameter	Maximum Concentration mg/l
Arsenic	.050
Barium	1.
Cadmium	.010
Chromium	.050
Copper	1.
Lead	.050
Mercury	.002
Selenium	.010
Silver	.050
Zinc	5.

All concentrations listed are mg/L.

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or contribute to, a condition of air pollution." "Air pollution" is defined as the presence in the atmosphere of one or more air contaminants or a combination thereof, in such concentration and of such duration as may tend to be injurious to or to adversely affect human health or the environment, animal life, vegetation or property, or as to interfere with the normal use and enjoyment of animal life, vegetation, or property. The Texas Air Control Board uses screening leads to interpret adverse concentrations in air. These concentrations generally relate to occupational health exposure limits.

To assure compliance with this standard, the proposed remedial action plans must contain provisions for ambient monitoring to verify that site conditions existing at the completion of remediation are not causing or contributing to a condition of air pollution.

6. Release from Solid Waste Units

The RCRA regulations under 40 CFR Part 264 Subpart F establish maximum contaminant concentrations that can be released from hazardous waste units. Although there are no hazardous waste units on-site, the RCRA regulations do consider releases of hazardous substances into groundwater. Therefore, these requirements are "relevant and appropriate." These RCRA requirements are identical to the Safe Drinking Act MCLs.

3.3 Location-Specific ARARs

Location-specific ARARs are requirements that set restrictions on activities based upon the characteristics of the site and nearby suburbs. Tables 3-4A and 3-4B present a review of the Federal and State potential location-specific ARARs.

3.4 Action-Specific ARARs

ARARs applicable to the development of the remedial action alternatives for the Koppers South Cavalcade site deal with Federal and State requirements for the degree of remediation at the site. Table 3-5A and 3-5B present a detailed evaluation of Federal and State action-specific ARARs.

3-6a

TABLE 3-4A

FEDERAL LOCATION-SPECIFIC ARARs

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant and Appropriate	Comment
National Historic Preservation Act	49 U.S.C. 470 40 C.F.R. 6.301(b) 36 C.F.R. Part 800	Requires Federal agencies to take into account the effect of any Federally-assisted undertaking or licensing on any district, site, building, structure or object that is included in or elegible for inclusion in the National Register of Historical Places	No/No	There are no items located on site which are eligible for inclusion on the National Register of Historical Places.
Archeological and Historical Preservation Act	16 U.S.C. 469 40 C.F.R. 6301(c)	Establishes procedures to provide for preservation of historical and archeological data which might be destroyed through alteration of terrain as a result of a Federal construction project or a Federally licensed activity or program	No/No	No historical or archeological data is at the site.
Historic Sites, Buildings and Antiquities Act	16 U.S.C. 461-467 40 C.F.R. 6.301(a)	Requires Federal agencies to consider the existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks.	No/No	There are no items located on site which are on the National Registry of National Landmarks.

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TABLE 3-4A (continued)

FEDERAL LOCATION-SPECIFIC ARARs

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant and Appropriate	Comment
Fish and Wildlife Coordination Act	16 U.S.C. 661-666	Requires consultation when Federal department or agency prooses or authorizes any modification of any stream or other water body and adequate provision for protection fish and wildlife resources.	No/No	There is no water body nearby which could be potentially modifided.
Endangered Species Act	16 U.S.C. 1531 50 C.F.R. Part 200 50 C.F.R. Part 402	Requires action to conserve endangered species within critical habitats upon which endangered species depend, includes consultation with Department of Interior.	No/No	The U.S. F.W.S has found no endangerment species at the site.
Clean Water Act	33 U.S.C. 1251-1376			
Dredge or Fill Requirements (Section 404)	40 C.F.R. Parts 230-231	Requires permits for discharge of dredge or fill material material into navigable waters	No/No	There will be no discharge of these materials into navigable waters.
Rivers and Harbors Act of 1899	33 U.S.C. 403			
Section 10 Permit	33 C.F. R. Parts 320-330	Requires permit for structures or work in or or affecting navigable waters.	No/No	No remedial alternative includes structures or work in or affecting navigable waters

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TABLE 3-4A (continued)

FEDERAL LOCATION-SPECIFIC ARARs

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant and Appropriate	Comment
Executive Order on Protection of Wetlands	Exec. Order No. 11,990 40 C.F.R. 6.302(a) and Appendix A	Requires Federal agencies to avoid to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practical alternative exists.	No/No	The site does not include wetlands
Executive Order on Floodplain Management	Executive Order No. 11,988	Requires Federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid, to the adverse impacts associated with direct and indirect development of a floodplain	No/No	The site is not within the 100-year floodplain.
Wilderness Act	16 U.S.C. 1131 50 C.F.R. 35.1	Administer Federally owned wilderness area to leave in unimpacted.	No/No	No wilderness area on-site or adjacent to the site.
National Wildlife Refuge System	16 U.S.C. 668	Restricts activites within a National Wildlife Refuge	No/No	No wilderness area on-site or adjacent to the site.
Scenic River Act	16 U.S.C. 1271 40 C.F.R. 6.302(e)	Prohibits adverse effects on a scenic river	No/No	No scenic river in area.

TABLE 3-4B

STATE LOCATION - SPECIFIC ARARs

Standard, Requirement, Criteria, or Limitation	State Agency	Description	Applicable/ Relevant and Appropriate	Comment
Location-Specific				
Location of Wells Used for Drinking Water Supplies	Department of Health	Restricts the placement of wells used for drinking water, and the location of solid waste disposal.	Yes/No	Requires institutional controls if the remedy constitutes RCRA defined disposal.

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TABLE 3-5A

FEDERAL ACTION-SPECIFIC ARARs

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant and Appropriate	Comment
CLEAN WATER ACT	33 U.S.C. 1251-1376			
National Pollutant Discharge Elimination System	40 C.F.R. Part 125	Requires permits for the discharge of pollutants for any point source into waters of the United States.	Yes/No	A permit will be required for discharge to Hunting Bayou if on-site ground water treatment occurs and is discharged to Hunting Bayou.
Effluent Guidelines and Standards for the Point Source Category	40 C.F.R. Part 414	Require specific effluent characteristics for discharge under NPDES permits.	No/No	No direct applicability because there is no on-going commercial activity.
National Pretreatment Standards	40 C.F.R. Part 403	Sets standards to control pollutants which pass through or interfere with treatment processes in public treatment works or which may contaminate sewage sludge.	Yes/No	Only if the selected alternative includes discharge to a pu... ..ly owned treatment works.
SOLID WASTE DISPOSAL ACT ("SWDA")	42 U.S.C. 6901-6987			
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 C.F.R. Part 257	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on public health or the environment and thereby constitute prohibited open dumps.	Yes/No	Only if a selected alternative includes on-site disposal

TABLE 3-5A (Continued)

FEDERAL ACTION-SPECIFIC ARARs

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant and Appropriate	Comment
Hazardous Waste Management Systems	40 C.F.R. Part 260	Establishes procedure and criteria for modification or revocation of provisions in 40 C.F.R. Part 260-265.	No/No	Creates no substantive cleanup requirement.
Standards Applicable to Generators of Hazardous Waste	40 C.F.R. Part 262	Establishes standards for generators of hazardous wastes.	No/Yes	If remedial action alternative involves off-site transportation of either soil or groundwater for treatment or disposal.
Standards Applicable to Transporters of Hazardous Waste	40 C.F.R. Part 263	Establishes standards which apply to transporters of hazardous waste within the U.S. if the transportation requires a manifest under 40 C.F.R. Part 262.	No/Yes	If remedial action alternative involves off-site transportation of either soil or groundwater for treatment or disposal.
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 C.F.R. Part 264	Establishes minimum national standards which define the acceptable management of hazardous wastes for owners and operators of facilities which treat, store or dispose of hazardous wastes.	No/Yes	The site contains no RCRA listed hazardous wastes, however, part 264 requirements may be relevant and appropriate for certain remedial actions. See each Subpart below.

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TABLE 3-5A (Continued)

FEDERAL ACTION-SPECIFIC ARARs

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant and Appropriate	Comment
General Facility Standards	Subpart B		No/Yes	Relevant and appropriate if any remedial actions are selected for which other Subparts of 264 are relevant and appropriate.
Preparedness and Prevention	Subpart C		No/No	No substantive cleanup requirement
Contingency Plan and Emergency Procedures	Subpart D		No/No	No substantive cleanup requirement
Manifest System, Record-keeping, Reporting	Subpart E		No/No	No substantive cleanup requirement.
Releases from Solid Waste Management Units	Subpart F		No/Yes	If and alternative results in releases from on-site solid waste management units established as a remedial action.
Closure and Post-Closure	Subpart G		No/Yes	CERCLA establishes review of remedial actions should contaminants be left on site. RCRA substantive requirements include deed notices and monitoring.
Financial Requirements	Subpart H		No/No	No substantive requirements.

TABLE 3-5A(Continued)

FEDERAL ACTION-SPECIFIC ARARs

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant and Appropriate	Comment
Use and Management of Containers	Subpart I		No/Yes	If an alternative would involve storage of containers.
Tanks	Subpart J		No/Yes	If an alternative would involve use of tests to treat or store hazardous materials.
Surface impoundments	Subpart K		No/Yes	If an alternative will involve a surface impoundment to treat, store or dispose of hazardous materials.
Waste Piles	Subpart L		No/Yes	If an alternative would treat or store hazardous materials in piles.
Land Treatment	Subpart M		No/Yes	If an alternative would involve land treatment.
Landfills	Subpart N		No/Yes	If an alternative would involve disposal of hazardous materials in a landfill.
Incinerators	Subpart O		No/Yes	If an incinerator alternative is developed.

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TABLE 3-5A (Continued)

FEDERAL ACTION-SPECIFIC ARARs

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant and Appropriate	Comment
Interim Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities	40 C.F.R. Part 265	Establishes minimum national standards that define the acceptable management of hazardous waste during the period of interim status and until certification of final closure or if the facility is subject to post-closure requirements, until post-closure responsibilities are fulfilled.	No/No	Remedies should be consistent with the more stringent Part 264 standards as these represent the ultimate RCRA compliance standards and are with CERCLA's goal of long tera protection of public health and welfare and the environment.
Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities	40 C.F.R. Part 266	Establishes requirements which apply to recyclable materials that are reclaimed to recover economically significant amounts of precious metals.	No/No	Does not establish additional cleanup requirements.
Interim Standards for Owners and Operators of New Hazardous Waste Land Disposal Facilities	40 C.F.R. Part 267	Establishes minimum standards that define acceptable management of hazardous wastes for new land disposal facilities.	No/No	Remedies should be consistent with the more stringent Part 264 standards as these represent the ultimate RCRA compliance standards and are consistent with CERCLA's goal of long term protection of public health and the environment.

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TABLE 3-5A (Continued)

FEDERAL ACTION-SPECIFIC ARARs

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant and Appropriate	Comment
Land Disposal	40 C.F.R. Part 268	Establishes restriction for burial of wastes and other hazardous materials.	No/Yes	If an alternative developed would involve burial of contaminated soils or residues.
Hazardous Waste Permit Program	40 C.F.R. Part 270	Establishes provisions covering basic EPA permitting requirement.	No/No	A permit is not required for on-site CERCLA response actions. Substantive requirements are addressed in 40 C.F.R. Part 264.
Underground Storage Tanks	40 C.F.R. Part 280	Establishes regulations related to underground storage tanks.	No/No	No alternative involving the use of underground tests is anticipated.
OCCUPATIONAL SAFETY AND HEALTH ACT	29 U.S.C. 651-678	Regulates worker health and safety.	Yes/No	Under 40 C.F.R. 300.38, requirements of the Act apply to all response activities under the NCP.
SAFE DRINKING WATER ACT	40 C.F.R. Parts 144-147			
Underground Injection Control Regulations	40 C.F.R. Parts 144-147	Provides for protection of underground sources of drinking water.	Yes/No	If a groundwater remediation involves injection to enhance cleanup.
HAZARDOUS MATERIALS TRANSPORTATION ACT	49 U.S.C. 1801-1813			
Hazardous Materials Transportation Regulations	49 C.F.R. Parts	Regulates transportation of hazardous materials.	Yes/No	If an alternative developed would involve transportation of hazardous materials.

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TABLE 3-5B

STATE ACTION-SPECIFIC ARARs

Standard, Requirement, Criteria, or Limitation	State Agency	Description	Applicable/ Relevant and Appropriate	Comment
Action Specific				
Storage of Volatile Organic Compounds	Air Control Board	Regulates handling of tanks containing volatiles.	Yes/No	Only an ARAR if volatiles will be contained in a tank.
Control of Groundwater Withdrawal	Harris-Galveston Coastal Subsidence District	Controls the withdrawal of groundwater in Harris County.	No/No	The District rules exempt groundwater remediation.
Oil/Water Separators	Air Control Board	Requires methods for minimizing emissions from separators.	Yes/No	If oil/Water separation is a part of the groundwater remediation.
Vacuum Producing Systems	Air Control Board	Requires incineration of emissions above threshold.	Yes/No	If vacuum recovery is a part of groundwater remediation.
Vent Gas Streams	Air Control Board	Requires incineration of emissions.	No/No	Not characteristic of the site.

1. NPDES

During remediation, CERCLA 121(d) requires that storm water discharges and remedial-activity generated discharges meet the pollutant limitation and performance standards included in the Clean Water Act. The wastewater treatment technology proposed in response alternatives for CERCLA sites are required to meet the equivalent of best conventional pollutant control technology (BCT)/best available technology economically achievable (BAT). EPA has promulgated technology-based requirements through effluent limitation guidelines for specific categories of industries with on-going commercial activities, which are then transferred into specific discharge limits by NPDES permit writers. Where effluent guidelines for a specific industry or industrial category do not exist, e.g., Superfund sites, technology-based treatment requirements equivalent to BCT/BAT will be determined by EPA on a case-by-case basis using best professional judgment (BPJ) in accordance with CWA 402(a)(1)(B) and 40 CFR 125.3(c)(2). These requirements would continue to be enforced at the completion of the remedial action during the operation and maintenance of the remedy.

The NPDES regulations governing the methods for imposing BCT and BAT treatment require that EPA consider the appropriate technology for the category or class of point sources of which the applicant is a member [40 CFR 125.3(c)(2)(i)]. The previous operation at the South Cavalcade site was wood preserving using creosote and wood treating salts. The applicable effluent limitations for these activities are found in 40 CFR 429 which require no discharge of water containing process related contaminants. However, Part 429 is neither applicable nor relevant and appropriate because these requirements pertain solely to operation and not closure of a wood preserving site.

2. Solid Waste Disposal Act (SWDA)

General RCRA Requirements - The Solid Waste Disposal Act was amended by the Resource Conservation and Recovery Act (RCRA) to control hazardous substances. The provisions of RCRA pertinent to the South Cavalcade site have been promulgated under 40 CFR Parts 257, 260, 261, 262, 263, 264, 268, and 280. EPA considers that the above regulations are "applicable" to RCRA characterized or listed hazardous wastes (40 CFR Part 260) which either: 1) were disposed at a site after November 19, 1980; or 2) the CERCLA remedial action consists of treatment, storage, or disposal as defined by RCRA (40 CFR Part 264). In addition, these regulations are "relevant and appropriate" to RCRA hazardous wastes disposed at a site prior to November 19, 1980.

Potential contaminants of concern (PCOC) for the South Cavalcade site have been identified and are similar, but not identical to those regulated under 40 CFR Parts 262-265, 270 and 271. The wood preserving plant ceased operation in 1962; the wastes were disposed on-site prior to November 19, 1980. Therefore, the RCRA regulations are only "relevant and appropriate" for any activities resembling RCRA regulated activities.

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RCRA permits are not required for portions of CERCLA actions taken entirely on-site. Therefore, administrative RCRA requirements (i.e., reporting, record keeping, etc.) are not "applicable or relevant and appropriate" for on-site activities. However, all hazardous wastes disposed off-site are required by CERCLA 121 (d)(3) to be in compliance with all pertinent RCRA requirements.

<u>RCRA Storage Requirements</u> - EPA defines storage under RCRA to be RCRA hazardous wastes which are held for a temporary period, at the end of which the hazardous waste is treated, disposed, or stored elsewhere (40 CFR 260.10). The RCRA requirements are "applicable" to activities of this type. In some cases, the hazardous waste may first become subject to regulation as a result of the action taken at the cleanup site. If the party(s) conducting the cleanup are considered the generators of the waste, 40 CFR 262.34 provides that, under certain conditions, the waste may be stored for 90 days before the RCRA Part 264 requirements become "applicable". Otherwise, the RCRA requirements are "relevant and appropriate".

In the case of the South Cavalcade site, the RCRA requirements are "relevant and appropriate" for all storage activities because the actions governed by the requirements are sufficiently similar to those which may take place, and the wastes are not RCRA hazardous wastes.

RCRA Treatment Requirements - CERCLA 121 establishes a preference for remedial actions involving treatment that permanently and significantly reduces the volume, toxicity, or mobility of the hazardous substance, pollutants, and contaminants at the CERCLA site. The RCRA requirements are "applicable" at the site if 1) the waste is a RCRA hazardous waste, 2) the treatment complies with the RCRA definition contained in 40 CFR 260.10 and 3) the special jurisdictional prerequisites in the pertinent subpart for each category of treatment are satisfied. Otherwise, the RCRA requirements are "relevant and appropriate".

The RCRA requirements are only "relevant and appropriate" for other treatment units because they are well suited for the particular remedial actions being proposed, and they are not RCRA hazardous wastes.

RCRA Disposal Requirements - EPA has defined disposal under RCRA to be the movement (grading, excavation, etc.) of a RCRA hazardous waste originally disposed before the 1980 effective date of RCRA from within a "unit area of contamination". The RCRA requirements are "applicable" to activities of this type, and "relevant and appropriate" to similar activities.

In the case of South Cavalcade as with many CERCLA sites, there is no defined RCRA type "unit", but rather an "area of contamination" with differing wastes types and levels of contamination. Excavation, treatment, and encapsulation conducted within areas of soil contamination would be within the "area of contamination" and not conform to the RCRA definition of disposal. Therefore, the RCRA requirements are not "applicable". The RCRA requirements are "relevant and appropriate" for on-site activities, which means that the design and operating RCRA requirements are used. These include design requirements for landfills (including waste piles during construction of surface impoundments and land treatment units) and land disposal requirements. Any transport of wastes off-site does fall under the definition; the RCRA requirements are "applicable" in this case.

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Land Disposal Requirements - The disposal of RCRA hazardous waste during the course of remedial action may also be subject to the special restrictions on land disposal of hazardous waste established by the Hazardous and Solid Waste Amendments of 1984 (HSWA). According to HSWA, all RCRA hazardous wastes are to be reviewed by EPA to determine if they should be banned from land disposal. Banned waste cannot be placed in or on the land unless they have been first treated to levels achievable by best demonstrated available technology (BDAT) for each hazardous constituent in the waste.

EPA has defined placement and disposal to be identical. As previously discussed, the RCRA disposal regulations are considered to be "relevant and appropriate" for the South Cavalcade site; the Land Disposal Requirements can only be "relevant and appropriate". However, EPA has not yet proposed nor promulgated BDAT standards for CERCLA soil and debris. Therefore, the Land Disposal Restrictions will become "relevant and appropriate" when EPA promulgates these regulations. Also, HWSA includes an exemption until November 8, 1988, from the Land Disposal Restrictions for CERCLA soil and debris collected under CERCLA section 104 and 106 actions.

3. State Clean Air Act

Section 115.141, "Oil/Water Separators," requires use of a scaled vessel, floating roof, or vapor recovery system for separators with over a 200 gpd capacity operating on volatile compounds with a vapor pressure greater than or equal to 1.5 psia. Section 115.152, "Vacuum Producing Systems," requires incineration or equivalent of emissions exceeding 100 lb per 24 hours.

Regulation V (31 TAC Chapter 115), "Control of Air Pollution from Volatile Organic Compounds," Section 115.101, requires that the storage of volatile organic compounds with a vapor pressure of equal to or greater than 1.5 psia in a stationary tank, reservoir, or other container must be capable of maintaining working pressure sufficient at all times to prevent any vapor or gas loss to the atmosphere or is equipped with a control device which provides substantially equivalent control.

4. City of Houston POTW Pretreatment Requirements

Any remedial alternative involving discharge of treated or untreated water into the municipal sewer system must insure compliance with the City of Houston industrial wastewater pretreatment regulations. These regulations protect the publicly-owned treatment works (POTWs) from accepting wastes which they are unable to effectively treat, or which may damage the POTW operation. The applicable regulations address maximum concentrations allowed in industrial discharges for certain pollutants. These pretreatment standards that must be considered in groundwater treatment alternatives for the South Cavalcade site are listed below.

Pollutant	Maximum Allowable Concentration
Oil & Grease	200 mg/L
Phenol	20 mg/L

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4.0 SCREENING OF REMEDIAL ACTION TECHNOLOGIES

This section of the FS identifies the remedial response objectives and summarizes the technical approach that was used to identify and screen remedial action technologies for managing the constituents of concern at the South Cavalcade Site. First, remedial response objectives and general response actions are identified, based upon site-specific information and environmental concerns. Second, for each general response, a list of remedial action technologies are identified and then screened. Screening of the technologies is based upon technical concerns. Finally, the technologies passing the screening process will be assembled and a comprehensive list of potential remedial action alternatives are listed in Section 5.0.

4.1 Objectives of Remedial Action

The objectives for remedial action at the South Cavalcade site have been investigated for the various contaminant pathways identified in the preliminary and final Public Health and Environmental Assessments. Table 4-1a lists the remedial action objectives and remediation requirements for protection of human health and the environment, compliance with ARAR's, and consistency with the NCP for the pathways of surface water, sediments, soils, groundwater and air. As presented in the Table, the following cleanup criteria for the pathways of concern at the site have been selected:

Surface Water

* Prevent deterioration of existing surface water quality during remediation.

Sediments

* Prevent deterioration of existing sediment quality during remediation.

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TABLE 4-1a

REMEDIAL ACTION OBJECTIVES
SOUTH CAVALCADE SITE

PATHWAY	OBJECTIVE	CRITERIA	REMEDIATION REQUIREMENTS	ADVANTAGES	RISK AND DISADVANTAGES
Surface Water	Prevent surface water degradation.	Maintain existing surface water quality.	Current situation. No action required.	No surface water water degradation.	Potential mobilized contaminants during remediation.
Sediments	Minimize further sediment contamination.	Maintain existing sediment quality.	Current situation. No action required.	No sediment degradation.	Potential mobilized contaminants during remediation.
Surface Soils and Surficial Soils	Prevent leaching and reduce risk of contact.	Attain site cleanup goals.	Containment, removal, or treatment of contaminants.	No further source to groundwater migration. Protect public health and environment.	Potential mobilized contaminants during remediation.
Groundwaters and Subsurface Soils	Prevent the vertical and offsite migration of contaminants to lower groundwater zones.	Performance driven to levels identified in the Final Public Health and Environmental Assessment.	Removal and/or treatment of contaminated shallow groundwaters.	Effective protection of public health from exposure risk to lower groundwater zones.	Potential exists for migration to lower groundwater zones zones if remediation is incomplete.
Air	Prevent degradation of air quality on- or off-site.	Maintain air quality at current levels.	Monitor during remediation.	No degradation of air quality.	Exposure during remediation.

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Surface and Surficial Soils (0-6 ft deep)

* Prevent continued migration to groundwater.
* Reduce risks to public health.

Subsurface Soils

* Minimize the leaching of groundwater.

Groundwaters

* Prevent the vertical migration of contaminants to lower groundwater zones or horizontal migration to off-site wells.

Air

* Prevent deterioration of air quality during remediation.

For the surface soils, subsurface soils and groundwaters at the site, the response objectives require that containment, excavation and/or treatment of soils and impacted shallow groundwaters be implemented to ensure that public health and the environment is protected. Therefore, cleanup levels for the contaminants of concern found in the media must be established.

Correspondingly, the response objectives for the surface waters, sediments, and air pathways require that present or currently existing quality be maintained. This will be accomplished by designing the remedial actions to minimize contaminant migration into these media.

4.1.1 Cleanup Goals

Cleanup goals are monitorable levels which are used during remedial actions to ensure the remedial objectives are attained. The remedial objectives for this site which require remedial goals, as previously defined in Section 4.1, are 1) reduce potential risks from exposure to surface and surficial soils, 2) reduce potential leaching of soil PCOCs to groundwater, and 3) reduce potential risks from migration of groundwater PCOCs to aquifers usable as water supplies. Based on the PHEA and the treatability leaching tests, the PCOCs which need remedial goals are PAHs in soils and PAHs, metals, and volatiles in groundwater.

Surface and Surficial Soils

Surface surficial soils can contain PAHs which may continue to leach into the groundwater or which may pose a risk if people become exposed to them. From the treatability study (Appendix A), only PAHs were observed to leach from soils following application of tap water. Presumably, some surface and surficial soils may continue to leach due to perculation of rainwater. The level of PAHs in soils which will not substantially leach will vary from site to site and also between areas inside a site due to various factors such as organic content, porosity, and water content. Therefore, a remedial goal cannot be set for soils to control leaching. Instead, the soils in the areas targeted for potential remediation must be sampled during the Remedial Design using a fine grid. Soil samples from each grid must be tested in a standard soil column leaching test to determine if they need remediation.

In addition to leaching, remedial goals are typically developed to prevent adverse risk to exposed populations. The PHEA in Section 2 evaluated exposures to on-site commercial occupants, construction workers, utility workers, and potential residents. The PHEA showed that most of the potential risk was associated with potentially carcinogenic PAHs. Based on remediating PAHs, the following possible remedial goals were developed from maximum risk calculations; the NCP requires that remedial goals prevent risks greater than 10^{-4}.

	10^{-4}	10^{-5}	10^{-6}
CURRENT EXPOSURE			
Utility Workers(ppm)	13,700	1,370	135
Commercial Occupants(ppm)	10,700	1,060	103
POTENTIAL EXPOSURE			
Construction Workers(ppm)	700	69	6
Potential Residents (ppm)	322	19	--

TABLE 4-2a (continued)

MASTER LIST OF POTENTIAL TECHNOLOGIES
FOR REMEDIATION OF SOILS AND GROUNDWATERS
AT THE SOUTH CAVALCADE SITE

ON-SITE WATER TREATMENT (continued)
Physical/Chemical Separation
Ion Exchange
Neutralization
UV/Chemical Oxidation
(H_2O_2 O_2 O_3)
Photolysis
Reverse Osmosis
Solvent Extraction
Wet Air Oxidation
Sonic Treatment

ON-SITE SOIL TREATMENT
Composting
Engineered BioDegradation System (EBDS[SM])
Incineration
Soil Washing
Stabilization
Thermal Desorption

OFF-SITE SOIL TREATMENT
Incineration

OFF-SITE WATER DISPOSAL
Industrial Treatment Facility
POTW
NPDES

ON-SITE SOIL DISPOSAL
Landfill

OFF-SITE SOIL DISPOSAL
Landfill

007787

The utility worker and commercial occupant scenarios represent potential risks based on current land use. Typically, a 10^{-5} cancer risk level is used for commercial and industrial developments. At this risk level, the remedial goal for current exposures is 1,060 ppm carcinogenic PAHs.

The parts of the site where PCOCs were observed in surface and surficial soils are already developed and to a large degree covered with reinforced concrete and buildings. The site is also surrounded on 3 1/2 sides by commercial and industrial development (chemical and oil storage tanks, warehouses, abandoned waste ponds, and office buildings). Future development is possible although unlikely, and residential development is very unlikely without destroying the present commercial structures. Therefore, a 10^{-4} cancer risk level and a corresponding 700 ppm carcinogenic PAH concentration are used for protecting human health from future exposures.

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Groundwater

Groundwater can also contain PCOCs which may pose a risk if people become exposed to them. From the Remedial Investigation report, PAHs were observed to migrate to lower depths. The PHEA in Section 2 explained that, due to fractures in clay layers (slickenslides) and an old well possibly serving as a conduit to lower aquifers, the groundwater concentrations in lower aquifers cannot be quantified. Therefore, it is necessary to remediate the upper aquifer to as close to drinking water quality as practical. The remedial goals for the two upper aquifers containing PCOCs are Maximum Contaminant Levels (MCLs) for metals and benzene, no detectable carcinogenic PAHs under current laboratory procedures, and no non-aqueous phase liquids (NAPLs).

4.2 Identification of Potential Remedial Technologies

The PHEA conducted for the South Cavalcade Site indicates that surface and surficial soils and shallow zone groundwaters of the site may potentially present an increased risk to public health and the environment. As an initial step in developing a complete listing of potential remedial action technologies for remediating the site, applicable general response actions were identified for the site soils and groundwaters.

In the FS process general response actions are identified to address all significant site problems and potential contaminant exposure pathways identified during the remedial investigation. EPA defines a general response action as "a response action category consisting of groupings of related response technologies that may be used for a specific site problem" (U.S. EPA 1985B). The general response actions form the basis for identifying potential site remediation technologies corresponding to each response action. The response actions identified for managing the soil and groundwater at the South Cavalcade Site are listed below.

General Response Actions

Soil	**Groundwater**
No Action	No Action
Containment	Containment
Excavation	Collection
In Situ Treatment	In Situ Treatment
On-site Treatment	On-site Treatment
Off-site Treatment	Off-site Disposal
On-site Disposal	
Off-site Disposal	

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A master list of technologies for remediation of the soils and groundwaters identified under each response action is presented in Table 4-2a. Detailed general descriptions of the technologies listed in the above table is included in Appendix B of this FS Report.

4.3 Remedial Technology Screening

4.3.1 Technical Criteria

The principal criteria used for the technical screening process included (i) the level of development of the technology and its performance record, (ii) limitations associated with the technology and its relationship to the site-specific conditions and

TABLE 4-2a

MASTER LIST OF POTENTIAL TECHNOLOGIES
FOR REMEDIATION OF SOILS AND GROUNDWATERS
AT THE SOUTH CAVALCADE SITE

<u>NO ACTION</u>
Monitoring
Limited Access
Deed Restrictions

<u>CONTAINMENT</u>
In Situ Isolation
Surface Cover
Surface Capping
Slurry Trench/Wall
Grout Curtain
Sheet Piles

<u>GROUNDWATER COLLECTION</u>
Pumping Wells
Interceptor Trenches
& Subsurface Drains

<u>SOIL EXCAVATION</u>
Complete
Partial

<u>IN SITU SOIL/GROUNDWATER TREATMENT</u>
Bioreclamation
Soil Flushing
Chemical Oxidation
Treatment
Soil Stripping

<u>ON-SITE WATER TREATMENT</u>
Activated Sludge
Aeration Tank
Fixed Film Biological
BioFlow^{SM}
Fluidized Bed Reactor
Sequencing Batch Reactor
Trickling Filter
Air and Steam Stripping
BioFiltration^{SM}
Carbon Adsorption
Chemical Oxidation
(H_2O_2,O_3,Cl_2)
Dissolved Air Flotation
Evaporation
Filtration

characteristics, (iii) the applicability of the technology to the waste material, and (iv) results of treatability investigations performed on the site soils and groundwater, as well as findings developed from similar remediation activities. These criteria were used to eliminate those technologies that would not address the problems at the site, or have not been found demonstrated (experimentally or in the field) to the extent necessary for remediating the constituents (PCOC's) of concern at the site.

Screening of the technologies with respect to the level of technical development dictate that only those technologies that have met a specific level of development will be considered for further review. In general, a technology's performance record, reliability and commercial-scale demonstration were considered in this phase.

Site-specific screening conditions entail the evaluation of each technology on the basis of applicability to the local conditions (geologic, hydrogeologic, hydraulic). Technologies that are incompatible with the on-site conditions were eliminated.

A waste-specific screening criterion was used to evaluate the technical feasibility of potential technologies. Those technologies or actions which are incompatible or ineffectual with the constituents of concern found on the site were eliminated from further evaluation.

Lastly, a screening of the technologies was performed based on results of treatability investigations conducted on the site soils and groundwaters (See Appendix A). In addition, laboratory and field data obtained from the remediation of similar soils and groundwaters was used to identify applicable technologies for the Cavalcade Site. Technologies identified to perform poorly in treating the constituents of concern were eliminated from further consideration.

4.3.2 Technical Screening

In the next step of the FS process, each remedial action technology is screened based on site applicability and technical feasibility. The technical criteria noted previously in Section 4.3.1 were used for performing this segment of the evaluation. Each of the technologies listed in Table 4-2a are evaluated with respect to the previous evaluation criteria. The rationale used for eliminating and retaining the various technologies are presented below.

NO ACTION

The National Contingency Plan (NCP) states that no action alternatives should be evaluated. This alternative provides an evaluation of baseline conditions against which other remedial alternatives may be compared. Under the no action alternatives, additional remedial activities would not be performed and all potentially contaminated soils and groundwater would remain in place.

Monitoring

A long-term monitoring program may be incorporated into an alternative as part of an institutional control. The monitoring program would be established to provide information so that it is possible to determine if potential health risks are increasing at the site. Monitoring may also be used with other alternatives. Monitoring was retained under the No Action category.

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Limited Access

Limited access can be considered as part of an institutional control. Limited access of a site may include the use of fences and/or no trespassing signs to aid in preventing trespassing populations from entering the site or portions of the site. A fence has previously been installed on the northern and southern portions of the property. As part of a limited access measure, the fence would have to be maintained. This option was retained.

Deed Notices

Deed notices may be used as an institutional control measure. Deeds for selected properties within a site may be modified to notice the presence of potential hazardous substances on that land. A typical example is a RCRA landfill. After a landfill has been closed, the deed for that land is modified to note that future disturbance (development, excavation, etc.) may expose potential hazardous substances; this would discourage site disturbances. This control measure may be appropriate for the South Cavalcade site and was retained for further evaluation.

CONTAINMENT

Surface Cover

Surface cover involves the installation of a physical barrier such as soil over the surface of contaminated soil. The barrier eliminates or reduces direct contact, minimizes fugitive dust emissions, and may assist in reducing potentially volatile gas emissions. This is an applicable technology for low mobility contaminated soils and surface materials, however it will provide no protection for contaminated groundwater. This technology was eliminated from further consideration.

Surface Capping

Capping is the process by which contaminated areas are covered with any of a variety of materials. The purpose of this action would be to either prevent direct contact with contaminated materials or to prevent the migration of contaminants from the site by either surface water runoff, direct contact, or gas migration. If direct contact is the only concern, a surface cover is often sufficient to provide control. However, in order to control migration, impermeable cover materials must be used for control. Impermeable materials can be used to prevent the contact of surface water with contaminated material into groundwater, and the movement of gaseous contaminants into the air.

Capping has been used successfully to prevent direct contact with contaminated materials and can be considered a proven technology for this application. Capping has been retained for further consideration.

Slurry Trench/Wall

Slurry trench/wall can be used to either divert groundwater flow away from a waste site or to contain groundwater within a waste site area. The use of a slurry trench/wall as a remediation technology is considered a relatively new one, and there are some uncertainties associated with its use. First, many of the installations have not been proven over a prolonged period of time, and therefore the lifetime of these barriers is unknown. Second, there are questions regarding the integrity of some of the barriers following installation. Because of the above limitations and the need to cross the railroad tracks the lack of impermeable lower layer to key into and the depth of contamination, this technology was eliminated.

Grout Curtain

Grout curtains can be used to control in situ containments by injecting a variety of fluids into subsurface strata to reduce water flow and strengthen the formation. In general grout curtains are best suited for sealing fractures, fissures, solution cavities and other voids in rock. It should be noted that grout curtains are generally more costly and have higher permeability than slurry walls, and are seldom used for groundwater flow in unconsolidated materials. The same concerns for slurry walls apply; therefore grout curtains have been eliminated from further consideration.

Sheet Piles

Sheet piling can be made of wood, pre-cast concrete, or steel. Wood is an ineffective long-term water barrier and concrete is used primarily where greater strength is required. Steel, when properly installed, is most cost-effective in terms of groundwater cutoff, but because of uncertain wall integrity, steel sheet piling is seldom used except for temporary construction dewatering or as erosion protection where some other barrier, such as a slurry wall, intersects flowing surface water. Because of the railroad track proximity and lack of long term performance, this technology has been eliminated.

GROUNDWATER COLLECTION

Pumping Wells

Pumping wells can be used at a site in several different ways to reduce the transport of contaminants from the site. The three main applications of groundwater pumping are: (i) pumping to lower a water table, (ii) pumping to contain a plume, and (iii) pumping for collection and treatment. It is possible to prevent the water table from coming in contact with contaminants in a waste site by lowering or re-routing the groundwater flow using pumping. A contaminated plume can be contained by pumping groundwater from the up-gradient side to the down-gradient side to prevent movement of the plume under the site. The final pumping technique would involve the removal of contaminated groundwater for treatment followed by recharge to the aquifer or discharge to a surface source. Submersible pumps or a well point system could be used.

At this site, pumping for collection and treatment would be employed. The results of pump tests indicate pumping is feasible, however, at low pumping rates. This technology will be retained for further evaluation.

Interceptor Trenches and Subsurface Drains

Subsurface drains and interceptor trenches include any type of buried conduit used to convey and collect aqueous discharges by gravity flow. Drains and trenches essentially function like an infinite line of extraction wells. They create a continuous zone of influence in which groundwater flows toward the drain or trench. Trenches and drains can be used to contain or remove a plume, or to lower the groundwater table to prevent contact of groundwater/surface water with waste material.

For shallow contamination problems, drains can be more cost-effective than well pumping, particularly in strata with low or variable hydraulic conductivity. Under these conditions, it may be difficult to design, and it would be cost-prohibitive to operate a well pumping system to maintain a continuous hydraulic boundary. Subsurface drains can have a higher operation and maintenance cost than pumping if sections of the trench system need to be excavated and replaced. Because of the shallow groundwater depth and the low recharge yields interceptor trenches and subsurface drains were retained for further consideration.

SOIL EXCAVATION

The removal of surface and surficial soils can be accomplished by either complete or partial excavation. Excavation is the process of removing solids and thickened sludge materials for treatment or disposal. Excavation is performed using any of a variety of mechanical means including draglines, backhoes, cranes, and clamshells. Excavation must be linked with ultimate treatment and disposal technologies once the materials have been removed.

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Complete excavation

Complete excavation is an accepted practice that can achieve environmentally acceptable results. Contaminant removal of the waste by this method can assure that all of the wastes have been addressed. Excavation above the water table can be performed using standard road construction equipment.

Excavation also requires site restoration activities such as backfilling, grading for natural drainage management, and planting a vegetative cover over the excavated areas. Backfilling can be achieved using treated soil, uncontaminated soils from an on-site borrow area or may require obtaining suitable soils from an off-site location.

Complete excavation at the South Cavalcade site would not be practical because most of the site is occupied with commercial operations, crossed by numerous utilities and large portions of the site are covered with concrete pavement. Complete excavation was eliminated from further consideration.

Partial Excavation

Partial excavation is an alternative to complete excavation for managing localized areas of high concentrations of contaminants at the site. Removal of these soils to the water table may reduce the environmental risk to a reasonable level by eliminating the majority of wastes. In most cases the excavation of hotspots can be performed by visual inspection, followed by analytical verification.

Partial excavation would be very similar to the complete excavation option. The difference would be that a predetermined contaminant level would be used to set limits for the excavation. Excavation would proceed until analytical data show that the level has been met. The total volume of material to be excavated would be dictated by the level used at the cut-off. The cut-off level would be determined by the use of a public health risk determination of the wastes, and the contaminated soil. Because of the localized nature of the contamination partial excavation was retained for further consideration.

IN SITU SOIL/GROUNDWATER TREATMENT

Bioreclamation

In situ bioreclamation is a treatment system that may be used for the reduction of biodegradable materials, which are present in contaminated groundwater or contaminated soil. The concept involves the use of microbial organisms, either already in place or introduced to the system from an outside source, for treatment of organic contaminants. In order to accomplish this, the groundwater or soils to be treated must be supplemented with both nutrients and a source of oxygen to accelerate the degradation process.

Although the wastes found at the site are biodegradable, there are many uncertainties associated with the use of this technology as a total treatment method. Much of the waste is highly concentrated within areas that are concrete paved; therefore installation of an in situ bioreclamation system under the concrete may not be cost effective but could be for the areas that are accessible.

In addition, laboratory testing of the site soils and groundwaters aerobic and anaerobically indicate that in-situ bioreclamation may be an effective means of treatment. See Treatability Study Report Appendix A. In situ bioreclamation was retained for further evaluation.

Soil Flushing

Organic and inorganic contaminants can be washed from contaminated soils by means of an extraction process termed soil flushing. Water or an aqueous solution is injected into the area of contamination where the constituents of concern are removed from the soil matrix and the resulting contaminant bearing solution is pumped to the surface along with existing contaminated groundwaters. Once the contaminant bearing water has been extracted it can be treated on-site and reinjected to the saturated zone.

Treatability testing conducted on the site soils and groundwaters indicate that two and three ring PAH compounds are not tightly bound to the soils at the site, and

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therefore can leach from the soil matrix if clean water is applied to the soil. As an in situ process, soil flushing has been retained for further evaluation.

Chemical Oxidation Treatment

Chemical oxidation treatment involves the use of a chemical reaction to immobilize, destroy or detoxify a site contaminant. This treatment can be performed by entraining air, hydrogen peroxide or ozone into a contaminated plume through an injection well system. The result is chemically oxidized subsurface constituents. The chemical oxidation process involves the breakdown of complex compounds into simpler compounds such as carbon dioxide and water.

This is not a proven technology and little documented information is available for treatment of the site specific contaminants. This technology has been eliminated from further consideration.

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Soil Stripping

Soil stripping is an emerging site restoration technology proven effective for removal of volatile organic compounds (VOCs), e.g., benzene, toluene and xylene, from contaminated soils in the unsaturated zone as a means of source control. In situ soil stripping involves the removal of VOCs from a soil matrix by mechanically venting air or steam through the unsaturated soil layer. The contaminated soils are gradually remediated as VOCs are stripped from the soil. Volatile compounds and soil moisture within the pore spaces are driven from the soil matrix into the air.

The movement of VOCs in the soil matrix is a function of several biological and physical-chemical processes including: (i) adsorption/desorption relationships of VOCs and the soil, (ii) volatility of specific soil contaminants, (iii) air advection through the soil, and (iv) biodegradability of contaminants. Two key factors that enhance the success of soil stripping are low soil moisture to provide for adequate advection and volatility of the contaminants to be stripped.

Soil stripping was not considered to be an appropriate technology for the removal of the majority of the coal tar related compounds at the site. In addition, this

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technology is not applicable to contaminants located in the saturated zone. This technology was not retained.

ON-SITE WATER TREATMENT

Aerobic Biological Treatment

Aerobic biological treatment utilizes microorganisms to degrade constituents of concern in wastewater. The two frequently used treatment schemes used are aeration tank and activated sludge. Activated Sludge treatment systems differ from an Aeration Tank treatment in that the activated sludge system utilizes solids settling and recycle as part of the process. The activated sludge process uses a biologically active slurry bacteria. Wastewater is injected into the aeration basin where microbial oxidation and assimilation (treatment) occur. In the basin, the organic components of the wastewater serve as carbon and energy sources for microbial growth. The organic matter is converted into microbial cell tissue and oxidized end products (mainly carbon dioxide). The mixture of the microbial mass and wastewater is referred to as the mixed liquor. After a specified period of time the mixed liquor or treated effluent is passed into a settling tank where the biomass is separated from the recycled wastewater (effluent). A portion of the settled biomass is recycled to the head of the aeration basin to maintain the desired mass of organisms in the basin. The remaining sludge is removed from the system for final stabilization and ultimate disposal. This sludge is referred to as waste sludge. The treated effluent is then left for discharge.

Because the anticipated 50 gallons per minute water flowrate is sufficient to maintain sludge circulation, the activated sludge aerobic treatment process was preferred over other aerobic processes, specifically aeration tank. Activated Sludge biological treatment was retained for further evaluation.

Fixed Film Biological

A fixed film reactor uses both adsorption and biodegradation as a means of treating wastewater. Constituents of concern are adsorbed from the wastewater onto a packed media within the reaction vessel. Environmental conditions that stimulate biological activity are maintained in the vessel. Fixed film reactors treat wastewaters

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containing PAHs, phenolics, volatile organics, inorganics, and dioxins/furans. Wastewaters which contain BOD and COD in the concentration range of 100 ppm are best suited for the fixed film process. This process can be used to treat groundwater or as a polishing step for process wastewater. Due to the high BOD and COD levels in the groundwater (in the neighborhood of 300 mg/l and 600 mg/l, respectively), this treatment system was not retained for further study.

BioFlow^{SM}

The BioFlow^{SM} treatment system was developed by Keystone for the remediation of wastewater from wood treating facilities. Constituents of concern are adsorbed from the wastewater onto a media within the reaction vessel. Biodegradation of the constituents is achieved by the biomass which has been acclimated to the waste stream. Biodegradation can occur either aerobically or anaerobically. Recycle through the system is used to maintain an optimum hydraulic retention time (HRT) for maximum treatment potential. Keystone has conducted bench and pilot scale testing waters with low levels of adsorbable and biodegradable chemicals. The BioFlow^{SM} system has shown to be most effective on waste streams with low organic levels. Due to the elevated BOD and COD levels, in the neighborhood of 300 mg/l and 600 mg/l, respectively, in the groundwater at the South Cavalcade Site this technology has not been retained for further evaluation. 007800

Fluidized Bed Reactor

A fluidized bed treatment system uses an upflow reactor vessel which contains a growth media (usually granular carbon). A biomass is introduced to the vessel where portions of the biological material are adsorbed onto the carbon. The biomass is acclimated to the waste stream before full operation of the unit begins. Constituents of concern are first adsorbed onto the carbon and then biodegradation begins. Wastewater is recycled to ensure an optimum HRT. The fluidized bed system has been found to work on waste streams with low levels of organics. Due to the elevated levels of BOD and COD in the groundwater at the South Cavalcade Site, this technology has not been retained for further evaluation.

Sequencing Batch Reactor

Sequencing batch reactor (SBR) treatment is an established technology that has had success in treating domestic wastewater. However, limited data exists on the application of this technology to industrial waste. The SBR system is essentially a fill and draw activated sludge process. Each tank in the SBR system is filled with wastewater during a discrete time period and operated in a batch treatment mode. After treatment, the mixed liquor is allowed to settle for an optimal time and then the clarified effluent is drawn off. The amount of water drawn from the system is dependant upon the desired HRT for the system.

The SBR system has demonstrated 99% removal of phenolics and 75 - 95% of organic carbon in some wastewaters. There is also some evidence that this system can remove organics from groundwater. Because SBR is a relatively new technology and has not been applied to PAH wastes, SBR has not been retained for further evaluation.

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Trickling Filter

Trickling filter in an aerobic biological treatment process which is usually used to remove soluble organic compounds found in wastewaters. Trickling filters, in some cases, are also used to achieve nitrification (the conversion of nitrogen in the form of ammonia to nitrate). The trickling filter process is based upon the principle in which a biological growth, attached to a nonmoving media converts, the soluble organics present in the wastewater into carbon dioxide (CO_2), water, and bacterial solids. This system differs from the Activated Sludge and Aeration Tank processes in that the microorganisms are attached to media fixed within the reactor rather than suspended within the reactor.

Keystone's experience indicates that the Activated Sludge process would produce a better effluent because the process allows more rapid biodegradation to occur. Trickling Filter was eliminated as a potential technology.

Air and Steam Stripping

Air or steam stripping units can be used for the treatment of waters contaminated with volatile organics and certain inorganic compounds such as ammonia or hydrogen sulfide. The contact of the water stream with a vapor (air or steam) in a packed tower can remove a wide variety of contaminants to nondetectable concentrations. The degree of removal efficiency depends on a number of factors, including water temperature, pH, vapor to liquid ratio, and tower design parameters. Due to the recent analysis that has shown that volatile compounds exist in the groundwater, air stripping has been retained. However, steam stripping was eliminated because no nearby steam source is available.

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BioFiltration℠

BioFiltration℠ is a proprietary process developed by Keystone Environmental Resources, Inc. for the treatment of organic wastewater. This technology combines the treatment capabilities of filtration, adsorption, and biodegradation into a single process for the treatment of organically contaminated water. A BioFiltration℠ treatment unit filters suspended solids and adsorbs organic constituents onto a soil bed of selected matrix materials which are simultaneously biologically regenerated. The composition of the soil matrix is dependent upon the particular effluent stream to be treated and is designed to provide the appropriate combination of permeability and adsorption capacity.

Groundwater requiring treatment is applied to the top of the bed, and suspended particulates are filtered out at the surface. Soluble organics are adsorbed as the solution water percolates down through the soil matrix. Concurrently, the soil matrix, which contains an acclimated microbial population, continually regenerates the adsorbent media in the soil matrix. The resulting treated water is collected in an underdrain system and then discharged or recharged.

Based on Keystones database, BioFiltration℠ is a viable technology; however it is still in its development stage and has not yet been demonstrated as a proven technology for the treatment of groundwater at the South Cavalcade Site. Therefore, BioFiltration℠ has not been retained for further consideration.

Carbon Adsorption

Carbon adsorption can be used to remove certain organics from water and vapor streams. The carbon adsorption process works best with chemicals which have low water solubility, high molecular weight, low polarity and a low degree of ionization. The carbon used in the adsorption process is regenerated by either thermal or solvent extraction of the constituents of concern. Carbon is generally more economical when used on low concentration waste streams, or as a polishing step for final treatment prior to discharge. Activated carbon has also been used for the removal of mercury from chlor-alkali waste streams and the treatment of plating wastes.

Adsorption of the organics from the site contaminated waters may prove to be a valid treatment process. Following physical/chemical separation of non-aqueous phased liquids, the relatively low levels of organics in the resulting waters make this a viable treatment option. The direct application of carbon adsorption has been investigated with the site specific waters. The results indicate carbon removed approximately 90% of the organic compounds in the waters and will therefore be retained for further evaluation.

Chemical Oxidation

Chemical oxidation is a process which involves the use of a strong oxidizing agent to breakdown complex organics. Chemical oxidation treatment has been used by industry for many years, and there is considerable information available regarding its use for treating industrial wastes. Typical oxidizing materials are chlorine dioxide, chlorine, ozone, and hydrogen peroxide. Keystone's experience in working with similar waste streams have indicated that ozone provides the most effective means for chemical oxidation of phenolic compounds. In order to be even more efficient in the destruction of toxic and hazardous materials, chemical oxidation can be combined with other technologies such as UV irradiation. This process is presently used for the destruction of phenols, cyanide, volatile organics and other complex organic compounds. It can be used for slurries, tars, and sludges, however, its primary use has been in the treatment of aqueous waste streams.

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This is an unproven technology and there is little documentation on the effectiveness of chemical oxidation on specific site constituents. This technology has not been retained.

Dissolved Air Flotation

Dissolved Air Flotation is a process generally used on waste streams where the specific gravity of the material to be separated is very close to water. These particles settle very slowly or not at all. It is much easier to float and remove them from the water surface than to attempt to sink them. The basic principle involved with dissolved air flotation is the fact that as the pressure increases on water, it is able to contain more dissolved air, nitrogen or other gas.

Laboratory testing on the site groundwater showed that the non-aqueous phased liquids are easily separated from the groundwater. DAF would be unnecessary unless groundwater pumping created an emulsion. To insure that an emulsions is not created, pumping will not be performed with centrifugal pumps. Dissolved Air Flotation was eliminated.

Evaporation

Evaporation is the process of removing volatile constituents from a solution or slurry by boiling. It can be used to concentrate an aqueous waste solution, separating the major portion of water from the nonvolatile components such as solids, dissolved salts, or nonvolatile organics.

Evaporation usually requires that heat be transferred from a heat source such as steam or hot oil through a heat transfer surface to the waste. This is an energy intensive process and does not offer a solution for proper disposal, since there will be an accumulation of solids. Evaporation was eliminated as a viable technology.

Filtration

Filtration is a physical process used to remove solid particles suspended in a fluid by passing the fluid through a porous media. Filtration can be used in the treatment of waste materials by either removing solids from a liquid waste stream or by dewatering sludge to reduce the volume of material being disposed. There are a number of different types of filtration processes including granular filter beds, fixed media filters and pressure filters. Filtration may be practical for use as a polishing treatment step and will be retained for further evaluation.

Physical/Chemical Separation

Physical/chemical separation is a process which is used to remove soluble and insoluble matter from wastewater streams. Chemical processes can transform soluble materials into an insoluble state. Physical/chemical action work together to flocculate and settle out the solids.

Physical/Chemical separation can be used as a pretreatment process. Treatability testing of South Cavalcade groundwater indicates that physical settling alone can remove a large portion of the suspended particles in the site waters. This pretreatment scheme has been retained for further evaluation.

Ion Exchange

Ion exchange removes ionic species, principally inorganics, from aqueous phase streams. When an aqueous solution comes in contact with the exchange resin certain ionic species attach to the resin. The resins can be recharged to produce a high concentration blowdown stream which can be treated in a more economical manner.

This treatment is primarily applicable to the treatment of inorganics with a high concentration of ionic species. Also, the levels of organics in the groundwater are too high for this treatment. This technology has not been retained.

Neutralization

Implementation of the neutralization process on a waste stream is generally a very simple endeavor. The desired pH is achieved by combining an alkaline stream with an acidic stream. Methods for implementation will vary according to the constituents of the waste stream and the chemicals(s) used for neutralization.

The pH of the groundwater ranges between 6.5 and 8.0, therefore no pH adjustment of the groundwater is required prior to treatment. However, pH adjustment may be necessary as part of the overall groundwater treatment system. Neutralization was retained as a viable technology.

UV/Oxidation

Ozone is a powerful oxidizing agent which has the ability to degrade organic compounds. The use of ultraviolet light in combination with ozone has been shown to enhance the reactivity of ozone with certain chemical constituents.

When supplied at a sufficiently high dosage rate, ozone or ozone/UV are capable of oxidizing selected organic compounds to carbon dioxide and water. Complete oxidation to carbon dioxide and water may not be required if the intermediate compounds formed are amenable to downstream treatment or suitable for discharge.

Ozone is an unstable compound and must be generated on-site. For commercial applications ozone is produced through the discharge of an electric current across an air stream containing oxygen. The ozone-enriched gas stream is contacted with the water targeted for treatment in a reaction vessel. In the ozone/UV process the reaction vessel is equipped with ultraviolet lights.

Several classes of organic compounds can be effectively treated by ozone and ozone/UV, including phenolic compounds, polycyclic aromatic hydrocarbons (PAH), and unsaturated hydrocarbons. The processes have also been shown effective for the oxidation of inorganics, including cyanide, sulfite, and sulfide. Ozone and ozone/UV are primarily utilized for the treatment of contaminants in their aqueous and gaseous phases.

Laboratory treatability investigations conducted on the site groundwater indicate that only a 50% reduction in phenol and PAH compounds could be attained. UV/Oxidation was therefore eliminated from further evaluation.

Photolysis

Photolysis using ultra-violet light can be used to "catalyze" or initiate the dechlorination of organic chemicals in either aqueous or solvent systems. Degradation products of these reactions include polymeric tars and oxygenated compounds.

Keystones data base indicates that Photolysis is not as effective as UV/Ozone oxidation, which only removed 50% of the contaminants according to treatability testing. Photolysis was eliminated as a viable technology.

Reverse Osmosis

Reverse osmosis is a process which uses a semi-permeable membrane to remove certain dissolved materials from aqueous solutions. The operation of this technology is very dependent on temperature, pH, concentration, polarization, membrane compaction, fouling or scaling tendencies, and the presence of chlorine. To prevent plugging of the membranes, the waste stream being treated must be free of oils, suspended solids and other materials. Reverse osmosis will effectively remove dissolved materials having a molecular weight of greater than 200.

Reverse osmosis is not generally applied to the treatment of complex level organic waters. This treatment is usually used for the removal of dissolved salts. In wastewater treatment, fouling of the membrane often occurs. This technology has not been retained.

Solvent Extraction

Solvent extraction uses the differences in solubility and selectivity between a solute and solvent to remove materials from solution. This process has been used extensively in the chemical industry and has become increasingly popular for treatment of aqueous wastes. One of the chief applications in the past has been for the removal of phenolic compounds from petroleum refineries, coke plant and phenol resin plant wastewater. This process is usually used for the treatment of high strength industrial wastes different from the site wastes. This technology has not been retained.

Wet Air Oxidation

Wet Air Oxidation is the oxidative degradation of organics in aqueous streams using air as the oxygen source. Destruction of most organics requires temperatures between 350 and 650°F and pressures of 1,000 to 3,000 psig. Wet Air Oxidation is an energy intensive process and is not applicable for the treatment of low level organic streams (<2%). Wet Air Oxidation has been eliminated as a viable technology.

Sonic Treatment

Sonic treatment can be used to break emulsions of hydrocarbons and water which may contain suspended solids. Mechanical energy in the form of sound or compression waves are transferred to the surface of dispersed droplets in the emulsion. This then ruptures the surface of the droplets and results in their coalescing into larger drops. The larger drops are then removed by settling or centrifugation.

Sonic treatment is only applicable for the removal of heavy oils such as those from a refinery. The oils at the site are not classified as heavy by nature, therefore this technology was eliminated from further consideration.

ON-SITE SOIL TREATMENT

Composting

Composting is a biological process used to treat solid waste materials with high concentrations of biodegradable organic solids. Composting is a series of continuous operations which consist of 1) mixing with a bulking agent such as wood chips to improve porosity and reduce moisture content, 2) decomposing of the mixture by aerobic micro-organisms, 3) curing of the mixture to permit stabilization and deodorizing, and 4) screening to recover bulking agents from the composite. This process applies best to high organic wastes such as biological treatment sludge.

The soil wastes at the site are not sludges and do not contain extremely high concentrations of organics. In addition, composting requires a large area and involves

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a long time period for remediation, therefore it was eliminated from further consideration.

Engineered BioDegradation System^{SM}

EBDS^{SM} is a biological treatment process developed by Keystone which utilizes the large microbial population naturally present in soil to biologically degrade organic wastes. This process can be performed on- or off-site, and is best applied to soils or wastes with a high solids content that can be biodegraded.

Waste or soil can be handled in a variety of manners, such as, plowing, disc harrowing, or other similar methods to minimize odors and provide good distribution. Mixing also provides aeration of the soils to enhance biological activity. Blending of highly contaminated soils with lesser contaminated soils is sometimes necessary depending upon the type and concentration of contamination. Typically, nutrients or fertilizer are required to maintain the proper microbial environment.

It has been Keystones experience that EBDS^{SM} is most economical when used for remediation of large volumes of contaminated soils. The estimated volume of soil for remediation at the South Cavalcade site does not warrant the use of EBDS^{SM}. Engineered BioDegradation System^{SM} was eliminated.

Incineration

Incineration process equipment is commercially available for the treatment of wastes. A number of factors must be examined in the evaluation of incineration treatment systems. These factors include: (i) the form of the waste (solid, liquid, or sludge), (ii) BTU content, (iii) temperature required to totally destroy the waste, (iv) waste volume, (v) co-generation feasibility, and (vi) the type of incineration equipment suitable for the particular application.

Combustion treatment processes for toxic materials include rotary kilns, calcination kilns, fluidized beds, multiple hearths, liquid injection and infrared incinerators. The primary differences between these systems are the types of supplemental fuels used for combustion, the maximum temperature which can be achieved, the type of wastes

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which can be fed into the combustion zone, and the residence time for the wastes fed into the system.

On-site incineration treatment is an acceptable practice that has been used at many waste sites. Therefore this technology will be retained.

Soil Washing

Soil washing utilizes the concept of waste removal from soils by mechanically washing the soil with water, solvent, or surfactant via mechanical agitation to separate the contaminants from the soil matrix. Air is sometimes used to aid in the scouring and separation process. The number of cycles or segments in the wash unit is dictated by the contaminant reduction level required, and upon the physical and chemical characteristics of the waste stream. Water and soil are usually introduced at opposite ends of the unit to provide a countercurrent contacting flow. The wash solution can be recycled through the unit until spent when it can either be treated and discharged or reused.

Treatability results conducted on the soils from the contaminated area indicate that 99% removal efficiencies of PAH compounds can be achieved (see Appendix A). Soil washing was retained for further consideration.

Stabilization

Stabilization has been referred to by a number of different terms, such as mineralization, solidification, fixation and encapsulation. All of these processes are similar in their goal to accomplish either (i) improving handling and physical characteristics for the waste material, (ii) decreasing surface area for the transfer or loss of pollutants from the waste, (iii) limiting the solubility of chemical constituents in the waste, and (iv) detoxifying chemical constituents in the waste. The primary methods of waste stabilization include cement-based processes, pozzolanic processes, thermoplastic techniques, organic polymer techniques and glassification.

This technology is highly sensitive to the organic content of the soil/waste. An organic content of as little as two percent has been found to detrimentally affect the matrix performance. Organic contaminants may leach from the matrix back into the environment or degrade over time and reduce the binding properties of the original stabilized material. Because the site soils contain less than 2% of organics this technology has been retained for detailed evaluation.

Thermal Desorption

Thermal desorption refers to the separation of chemical constituents that can be volatilized from nonvolatile solids, such as soil. It requires heating the solid to evaluate the vapor pressure of the chemical to enable diffusion through and volatilization from the solid in a reasonable time. Desorption temperatures are lower, and in most cases much lower, than the temperature required for thermally induced decomposition reactions (e.g., oxidation, pyrolysis) to occur. This distinguishes thermal desorption from incineration, in which combustion (destruction) of the contaminants is intended.

Thermal desorption can be performed in a variety of types of equipment which can provide adequate heat transfer and vapor release. As with incineration of soil, the total heat required is a function of the amount of moisture, and to a lesser extent organic content or total organic carbon content in the soil, and the temperature that must be achieved. Maximum solids temperatures required range from 150 to 500 oC. Volatile organic solvents can be desorbed using steam as a heat source; less volatile materials require higher temperature heat transfer fluids or a furnace.

Thermal desorption will not destroy metals and PAH compounds. In addition no steam source is immediately available; therefore this technology has been eliminated from further consideration.

OFF-SITE SOIL TREATMENT

Incineration

A description of incineration technology has been presented under the above general response category on-site soil treatment. The only off-site incinerator capable of handling the contaminated soils from the South Cavalcade site is located at Deer Park, Texas. This incinerator is operated by Rollins Environmental Services of Texas. This technology has been retained for further evaluation.

OFF-SITE WATER DISPOSAL

Industrial Water Treatment

Direct discharge of contaminated waters from a Superfund site to an operating industrial water treatment system is dependent on both the composition of the wastewater and the capacity of the system. Care must be taken to ensure that the additional pollutant loadings will not result in violation of the permitted discharge levels. Because transportation of the waters for treatment would involve trucking of a large volume of water, this option was eliminated from further consideration.

POTW

Direct discharge to a municipal water treatment system is dependent on the pretreatment standards of a particular treatment plants, the composition of the wastewater, and the capacity of the plant to accept additional wastewater. Keystone has done research on the use of co-treatability for the remediation of groundwater from treated wood sites. This research has given favorable evidence that a POTW would be able to treat wastewater such as the water at the South Cavalcade site.

In addition, preliminary analysis indicates that pretreatment utilizing oil/water separation with possible filtration could result in reducing PAH compounds such that they would not be detected in the POTW effluent stream. Because of the proximity of the Houston Municipal Treatment Works, this option was retained for further evaluation.

NPDES

On-site water treatment and subsequent disposal would involve obtaining an NPDES permit (set under the National Pollution Discharge Elimination Service) for discharge of treated waters to adjacent streams. These waters would have to meet discharge limitations for specific site related contaminants. This option would have to be used in conjunction with an on-site water treatment option. NPDES options have been retained for further evaluation.

ON-SITE SOIL DISPOSAL

Landfill

A secure landfill is a facility which provides long-term isolation of waste materials while minimizing the release of contaminants to the environment. Secure landfills are designed to limit the release of leached contaminants into the groundwater, runoff to surface waters, and dispersion into the air. Secure landfills are used for the disposal of a wide variety of solids and semi-solid materials. Materials may be prohibited on the basis of liquid content, reactivity, and/or the presence of highly toxic or unstable materials.

This technology does not treat or eliminate the need for long-term maintenance of the site. It also requires the use of a large area of unoccupied land. This technology was eliminated because it is felt that it will not meet the general response objective of preventing contamination of the lower groundwater zones.

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OFF-SITE SOIL DISPOSAL

Landfill

The description of a secure landfill is presented above. This technology has been retained because it is felt that removal of the contaminated hot spots would prevent degradation of lower groundwater zones. In addition, off-site landfill eliminates the need for long-term maintenance.

4.3.3 Summary of Technologies Passing Screening

The technologies suitable for remediation of the South Cavalcade site have been identified and a preliminary evaluation of their applicability has been completed. The technologies that were retained for further evaluation and subsequent development into remedial action alternatives are presented in Table 4-2b. Figures 4-1 and 4-2 present a block flow schematic representation of the technologies passing the screening process and their related process options for the soils and groundwater media, respectively. These technologies will be combined to form remedial action alternatives for cleanup of the soils and groundwaters at the site.

TABLE 4-2b

SUMMARY OF TECHNOLOGIES PASSING PRELIMINARY SCREENING FOR REMEDIATION OF SOILS AND GROUNDWATERS AT THE SOUTH CAVALCADE SITE

NO ACTION

Monitoring
Limited Access
Deed Notices

CONTAINMENT

Surface Capping

GROUNDWATER COLLECTION

Pumping Wells
Interceptor Trenches & Subsurface Drains

IN SITU TREATMENT

Bioreclamation
Soil Flushing

ON-SITE WATER TREATMENT

Activated Sludge
Carbon Adsorption
Filtration
Physical/Chemical Separation
Neutralization
Air Stripping

ON-SITE SOIL TREATMENT
Soil Washing
Stabilization
Incineration

OFF-SITE SOIL TREATMENT

Incineration

OFF-SITE WATER DISPOSAL

POTW
NPDES

OFF-SITE SOIL DISPOSAL
Landfill

007814

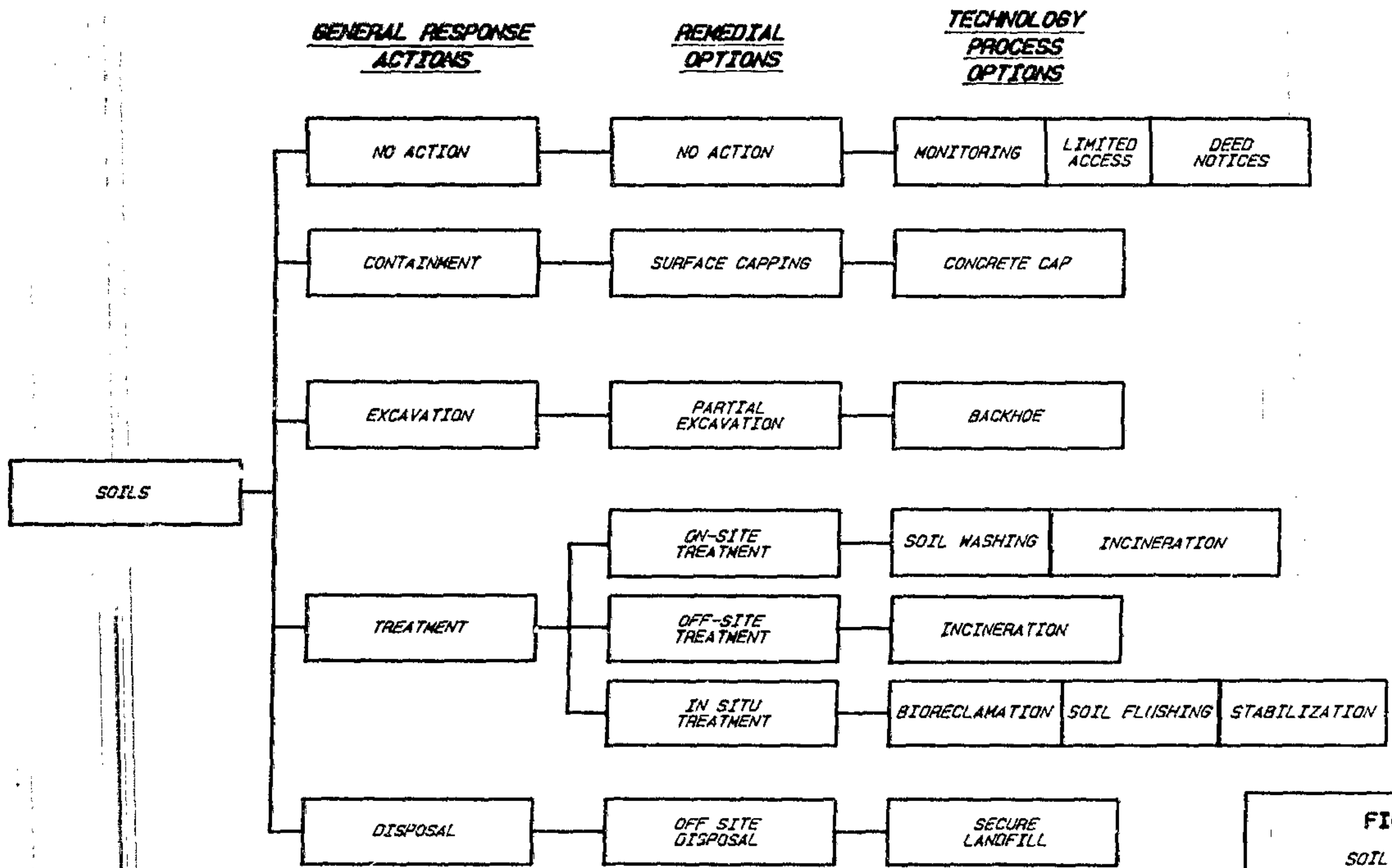

FIGURE 4-1

SOIL TECHNOLOGIES PASSING SCREENING
SOUTH CAVALCADE SITE
FEASIBILITY STUDY

KOPPERS COMPANY, INC. | C67559

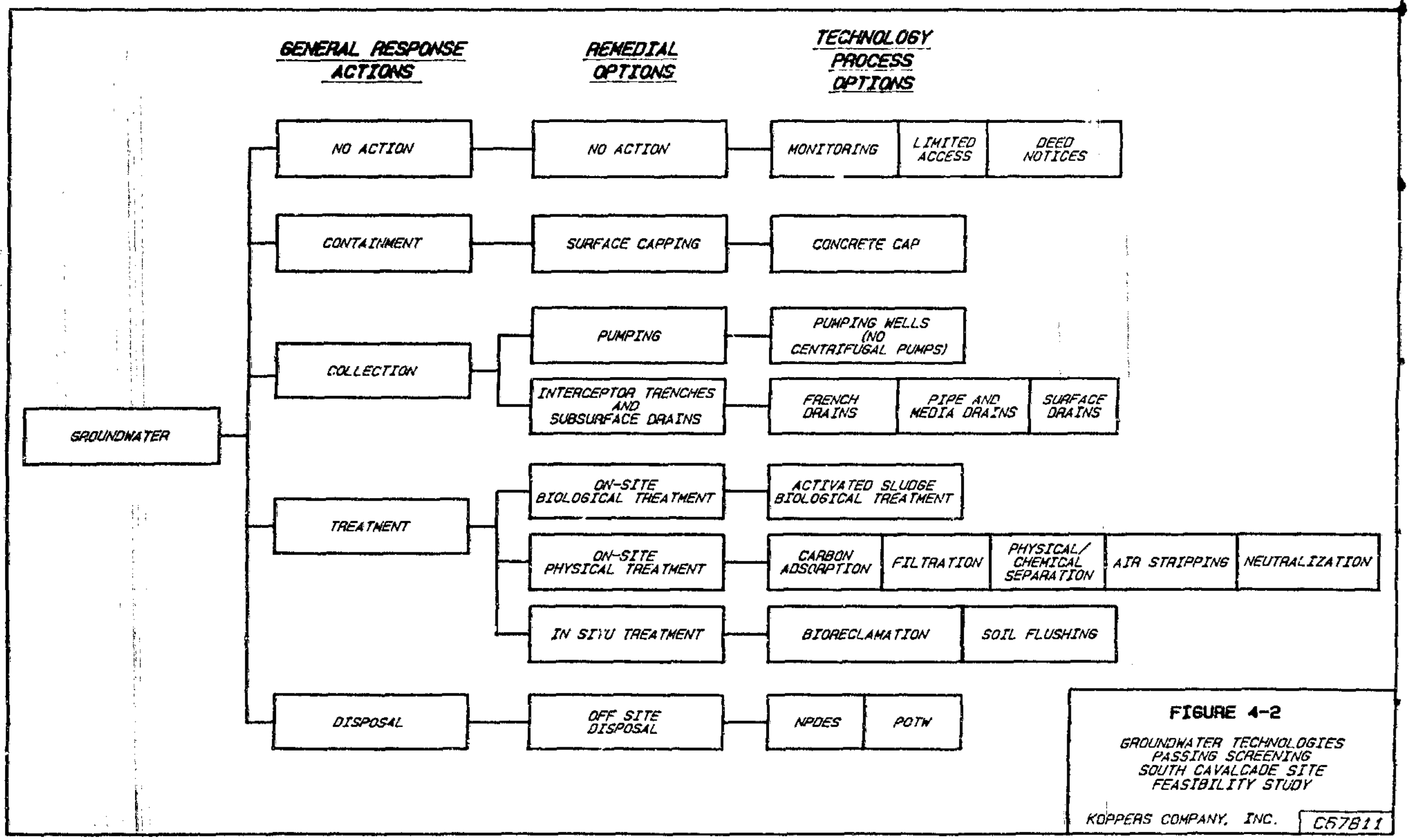

FIGURE 4-2

GROUNDWATER TECHNOLOGIES PASSING SCREENING
SOUTH CAVALCADE SITE
FEASIBILITY STUDY

KOPPERS COMPANY, INC. C57811

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5.0 DETAILED ANALYSIS OF REMEDIAL ACTION ALTERNATIVES

In this section of the FS the technologies passing the screening process are combined into complete alternatives for remediation of the site. These alternatives are then subjected to a detailed evaluation considering but not limited to the following factors: cost, implementability, effectiveness and the alternatives ability to reduce the mobility, toxicity, or volume of contaminants. The evaluation criteria is based on current and the new proposed requirements presented in SARA Section 121 for preparation of Records of Decision (RODs). The results of this detailed evaluation are summarized in Section 5.3 of this FS report.

5.1 Development of Remedial Action Alternatives

The objective of this segment of the Feasibility Study was to combine the technologies that passed the initial technical screening (See Section 4.0) to formulate potential site remedial action alternatives.

With the advent of the Superfund Amendments and Reauthorization Act (SARA) changes have occurred to the FS process, specifically pertaining to the selection of remedial actions. Section 121 of SARA states that: "Remedial actions in which treatment which permanently and significantly reduces the volume, toxicity, or mobility of the hazardous substance, pollutants, and contaminants is a principal element, are to be preferred over remedial actions not involving such treatment. The off-site transport and disposal of hazardous substances or contaminated materials without such treatment should be the least favored alternative remedial action where practicable treatment technologies are available." Therefore, the emphasis is on risk reduction or detoxification of hazardous waste by employing treatment technologies which reduce toxicity, mobility, or volume, rather than protection achieved through prevention of exposure. Remedial action alternatives which use treatment to reduce permanently and significantly the toxicity, mobility, or volume of wastes are preferred over RAAs that do not use such treatment.

In addition, SARA also states that a Remedial action alternative should be "protective of human health and the environment, cost-effective, and should utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable."

007817

A remedial action alternative that results in any contaminants remaining at a site must be reviewed no less often than every five years after the initiation of the remedial action alternative to assure that human health and the environment are being protected. Additional future action may be required at the site as a result of the review.

Pertaining to the degree of cleanup a remedial action alternative is required to attain, SARA states that the remedial action alternatives "shall attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further releases at a minimum which assures protection of human health and the environment." The remedial action alternatives must attain both federal and/or state applicable or relevant and appropriate requirements (ARARs).

A complete list of the alternatives developed for remediation of the soils and groundwater at the site is provided in Tables 5-1a and 5-1b, respectively. The alternatives and surface and surficial soil treatment and groundwater treatment options presented in the above tables were assembled to take into account all practical combinations of viable treatment technologies and identifies the alternative categories under SARA in which each technology belongs.

SARA Category	Description
1	No action
2	An alternative that minimizes the need for long term management (including monitoring) at the site.
3	An alternative that reduces the principal threat posed by a site through treatment, but would not necessarily involve treatment of all waste or treatment to the maximum extent possible.

TABLE 5-1a

SURFACE AND SURFICIAL SOIL REMEDIAL ALTERNATIVES FOR DETAILED EVALUATION

REMEDIAL ALTERNATIVE		SARA CATEGORY
1.	No Action	1
2.	In Situ Stabilization followed by Capping	3
3.	Excavation with Disposal at Off-Site Landfill	2,4
4.	Excavation with On-Site Treatment and Disposal.	
	On-Site Treatment Options Associated with Alternative 4	
	A. Soil Washing	2,3
	B. Incineration	2
5.	In-Situ Treatment	
	In-Situ Treatment Options Associated with Alternative 5	
	A. Bioreclamation	5
	B. Soil Flushing	2,3
6.	Excavation with Off-Site Treatment and Disposal	2

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TABLE 5-1b

GROUNDWATER REMEDIAL ALTERNATIVES FOR DETAILED EVALUATION

REMEDIAL ALTERNATIVE	SARA CATEGORY
1. No Action	1
2. Groundwater Collection and Aquifer Treatment (Bioreclamation) with Physical/Chemical Separation followed by Disposal.	3,5
3. Groundwater Collection and Aquifer Treatment (Soil Flushing) with On Site Groundwater Treatment followed by Disposal.	
Groundwater Treatment Options Associated with Alternative 3	
A. Physical/Chemical Separation followed by Granular Media Filtration and Activated Carbon Treatment.	2
B. Physical/Chemical Separation followed by Granular Media Filtration with Air Stripping and Activated Carbon Treatment.	2
C. Physical/Chemical Separation followed by Activated Sludge Biological Treatment.	2

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007820

4 An alternative that involves containment of waste with little or no treatment, but provides protection of human health and the environment.

5 An alternative that utilizes alternative treatment or resource recovery technologies.

In addition, the "No Action" alternative is always retained for use in baseline comparison for risk evaluation.

5.2 Criteria for Evaluation of Remedial Action Alternatives

The effectiveness of the alternatives will be assessed, taking into account whether or not an alternative adequately protects human health and the environment and attains Federal and State ARARs, whether or not it significantly and permanently reduces the toxicity, mobility, or volume of hazardous constituents, and whether or not it is technically effective over short- and long-term periods.

Alternatives will be evaluated against implementability factors, including the technical feasibility and availability of the technologies each alternative would employ, the technical and institutional ability to monitor, maintain, and replace technologies over time; and the administrative feasibility of implementing the alternative.

Finally, the costs of construction and the long-term costs of operating and maintaining the alternatives will be conducted using present worth analysis (based on a discount rate of 10% for an assumed projected life of 30 years). The alternative costs presented within this document exclude general mobilization, demobilization, and construction miscellaneous costs. These costs are understood to be cost estimates representing a -30 to +50 percent interval of the true cost of the alternatives.

5.3 Alternative 1: No Action

This alternative provides the baseline or reference point against which all other alternatives are compared. In the event that the other selected alternatives do not offer substantial benefits in reduction of toxicity, mobility, or volume, then the No Action Alternative may be considered a feasible approach.

5.3.1 Description

The no action alternative will consist of continued groundwater and soil monitoring, limited access and deed notices. Groundwater monitoring will consist of monitoring for PAH and volatile compounds and Priority Pollutant Metals on a twice a year basis. This monitoring scenario will be implemented to track the progress of the groundwater plume in the shallow groundwater zone and will be assumed to continue for a 30 year period some wells may need to be replaced over time. Access to the site is already limited in the northern and southern areas by chain-link fencing and security guard controlled entrances. Institutional controls utilizing deed notices will be implemented to inform property owners about the contaminants (PCOCs) at the site.

007822

5.3.2 Compliance with ARARs

The No Action Alternative involves the implementation of no clean-up activities. Groundwater in which the benzene and polynuclear aromatic hydrocarbons concentrations are greater than MCLs may be a threat to human health and the environment. As described in the Final Public Health and Environmental Assessment (Section 2.0), the shallow aquifer may potentially function as a source of PCOC contamination to the lower 220 and 550 foot aquifers if the no action alternative is implemented. Therefore, No Action Alternative may not attain the required ARARs.

5.3.3 Reduction of Toxicity, Mobility or Volume

No reduction of toxicity, mobility or volume will occur with the implementation of the No Action Alternative except that through natural biodegradation of organic PCOCs.

5.3.4 Short-Term Effectiveness

No short-term reduction in contaminants can be associated with the No Action Alternative. Semiannual periodic monitoring will occur only to determine if migration has effected the lower groundwater sources. In addition, there will be no increase potential risk to on site workers caused by any remedial activity.

5.3.5 Long-Term Effectiveness

The results of long-term monitoring will determine if and when the PCOCs in the shallow groundwater aquifer have impacted the lower 220 and 550 foot aquifers. Because the PCOCs can migrate, there may be potential exposure to groundwater users in the future; therefore, long-term monitoring of these aquifers will be necessary.

007823

5.3.6 Implementability

Monitoring during the no action alternative will occur on an semiannual basis. Only one new well will be installed downgradient of the contamination in the southern area. Monitoring would require that a field crew of two persons spending approximately six days per year be present for sample collection and submission to a laboratory. Data compilation and report submission would also be required. Signs noticing the presence of PCOCs can be implemented within the current federal, state, and local regulatory framework.

5.3.7 Cost

As provided in Table 5-2 the capital costs of $95,000 associated with the no action alternative are for the installation one deep well and casing and placement of signs. O & M cost for this alternative were estimated at $30,600 per year which includes sampling and analysis, replacement and administration costs and labor. Assuming a 10% interest rate and a projected 30 year monitoring period the associated present worth of this alternative has been estimated as $384,000.

TABLE 5-2

PRESENT WORTH COST SUMMARY FOR

ALTERNATIVE 1

NO ACTION

CONTINUED GROUNDWATER MONITORING WITH LIMITED ACCESS AND DEED RESTRICTIONS

Capital Cost		Cost ($)
1.	Well Installation Cost	50,000
2.	Signs	1,000
3.	Health and Safety during Construction	16,000
4.	Baseline Soils Sampling	9,350
	Capital Costs	76,350
	Contingency allowances (25% of Capital Costs)	19,088
Total Capital Costs		$95,438

Operation and Maintenance Costs		Costs ($/year)
1.	Sample Collection Costs	8,800
2.	Analyses of Samples	14,025
3.	Well Replacement Costs	5,000
	O & M Costs	27,825
Administrative costs (10% of O&M Costs)		2,783
Total O & M Costs		30,608
Present Worth ($) @ (10%-30 years)		$384,000

007824

Detailed and breakdowns for capital and annual operating costs are presented in Appendix C; Tables C-1 and C-2.

5.3.8 Overall Protection of Human Health and the Environment

The no action alternative will leave the site in its present condition. This alternative does not reduce or eliminate potential exposure and migration pathways for PCOCs. Potential risks exists to future workers if the site is developed or if utility work is required. PCOCs in the shallow aquifer may potentially migrate to the deeper aquifers. Future remediation of the site might be necessary if the site is developed.

SOIL ALTERNATIVES

5.4 Alternative 2: In Situ Stabilization followed by Capping

Alternative 2 provides for containment of the wastes and chemical fixation to prevent migration of the wastes and to prevent degradation of the lower groundwater zones.

5.4.1 Description

Stabilization has been referred to by a number of different terms, such as solidification, fixation, and encapsulation. For the South Cavalcade site, the primary purpose of stabilization would be to prevent leaching of contaminants from the treated soil zone. The stabilization process would be enhanced by covering the area with a concrete cap. The concrete cap would be effective in reducing leachate generation by limiting rain water from percolating through the treated zone.

The stabilization process would consist of mechanically loosening the contaminated soils, adjusting the soil moisture content, and then thoroughly mixing soil with stabilizing agents. The loosening and mixing would be accomplished within the treatment area using construction equipment (augers most practical). The primary stabilizing agent would be determined by bench scale tests during design. Additional additives incorporated into the mixture would be selected to further reduce solubility and leaching of the contaminants. Once adequately mixed, the material would be compacted and the top layer sloped to shed water. The compacted mixture would solidify in pla ; and mechanically lock the contaminants within the solid soil-additive matrix.

Following completion of the stabilization, a concrete cap would be constructed over the treated area. The cap will be sloped to drain. The surface of the concrete cap will be sealed and joints will constructed to prevent cracking and thereby reduce rain water infiltration. Figure 5-1 identifies the areas which would be capped under this alternative.

5.4.2 Compliance with ARARs

This alternative would meet all chemical and location ARARs. In addition, action-specific ARARs would be met by designing this option according to appropriate requirements.

5.4.3 Reduction in Toxicity, Mobility or Volume

In situ stabilization along with capping would reduce the mobility of site related constituents, but possibly not permanently. This option would not reduce the toxicity and volume of site contaminants.

5.4.4 Short-Term Effectiveness

This alternative would meet site remediation goals quickly. Total remediation will take approximately 10 to 12 months. The necessary stabilization and cap will prevent direct contact with contaminated soil in approximately a one year period. There is a small chance of commercial exposure during remediation. On-site workers conducting remediation activities would possibly be exposed to source material during site restoration. However, potential worker exposures can be reduced if these workers follow appropriate health and safety procedures.

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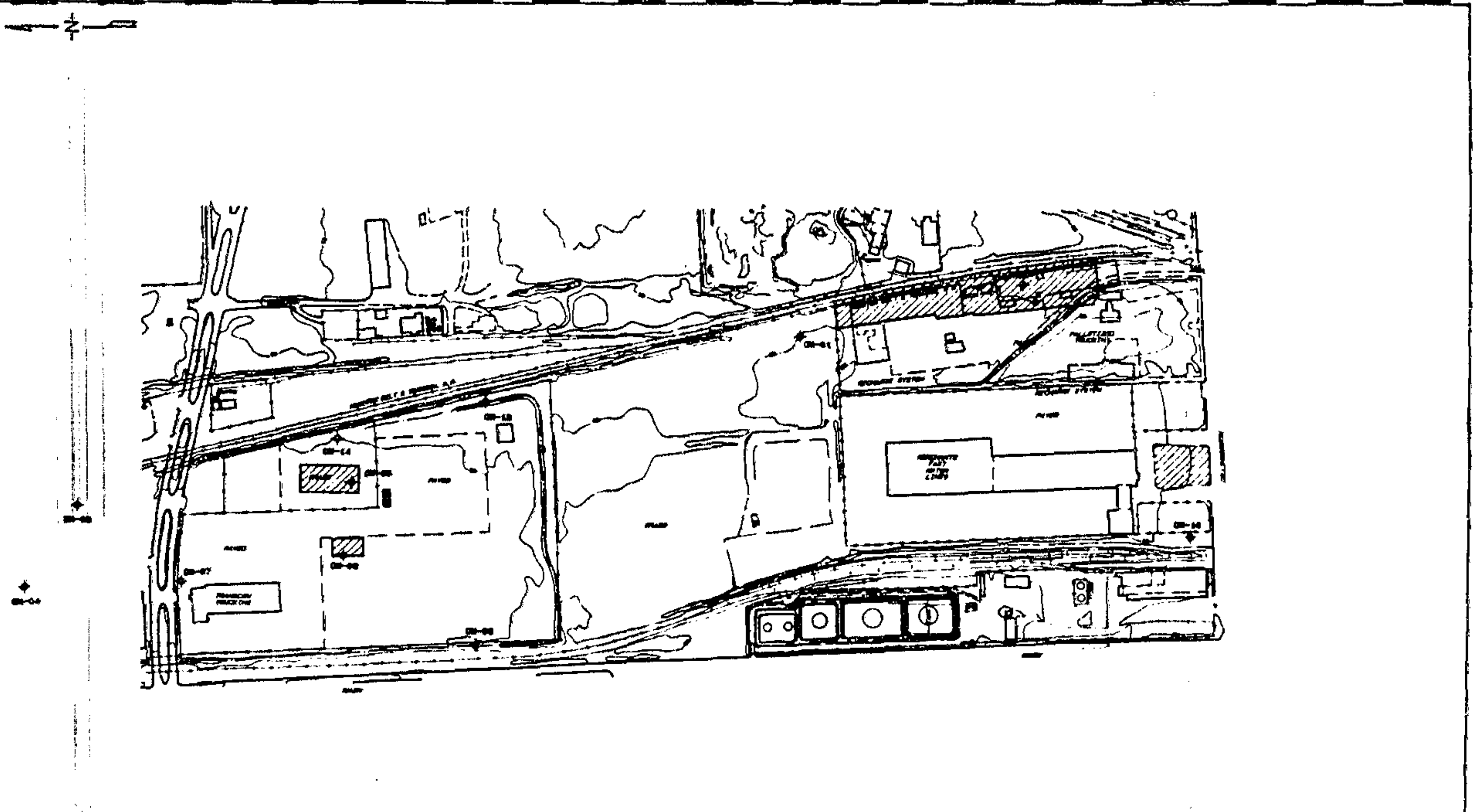
5-7a



LEGEND

APPROXIMATE AREA TO RECEIVE A CONCRETE CAP.

KEYSTONE ENVIRONMENTAL RESOURCES, INC

FIGURE 5-1

CONCRETE CAPPING LOCATIONS SOUTH CAVALCADE, TX

KOPPERS COMPANY, INC.

007827

5.4.5 Long-Term Effectiveness

In situ stabilization and capping would not eliminate the potential for future exposure to site materials. The alternative would only be as effective as long as the fixing agent continued to work as designed, and the cap remained intact. However, these containment actions will effectively reduce exposure and greatly reduce chemical migration as long as the site is maintained.

5.4.6 Implementability

This alternative may be implemented because it has been used at other CERCLA sites. The technology has been effectively used in this and other types of application. This alternative also would not be constrained by access problems. The equipment can be used at all areas of the South Cavalcade site. Prior to implementation laboratory studies would be needed to investigate the best fixing agent for this site. Furthermore, the fixing agent selected for stabilization would need to be field tested.

007828

5.4.7 Cost

The capital cost for the soil stabilization process are estimated to be about $14,288,000. The cost must be refined based on laboratory evaluations and a pilot study. The maintenance costs associated with the concrete cap are estimated at 10% of the concrete cap capital cost, about $50,000 per year. The total present worth of the stabilization and capping alternative is, therefore, about $14,800,000, assuming 30 year period at 10% interest. Table 5-3 presents this cost breakdown. Detailed cost analysis are presented in Appendix C in Tables C-3 and C-4.

5.4.8 Overall Protection of Human Health and the Environment

In situ stabilization and capping will greatly reduce or eliminate potential migration of potential contaminants, thereby reducing the possibility of long term exposure. Since in this alternative potential contaminants are only immobilized and not destroyed, there is potential risk to future workers if the site is developed of if utility work is required. This alternative does not eliminate the possibility of future site remediation if the stabilization fails.

TABLE 5-3

PRESENT WORTH COST SUMMARY FOR

ALTERNATIVE 2

IN SITU STABILIZATION FOLLOWED BY CAPPING

Capital Cost		Cost ($)
1.	Stabilization	9,271,000
2.	Concrete Cap	496,000
3.	Indirect Costs	1,663,500
	Capital Costs	$11,430,000
	Contingency Allowances (25% of Capital Costs)	2,857,000
	Total Capital Costs	$14,287,000
Operation and Maintenance Costs		**Costs ($/year)**
1.	Concrete Cap (10% of concrete cap capital cost)	50,000
Total O & M Costs		$50,000
Present Worth ($) @ (10%-30years)		$14,800,000

NOTE: Indirect costs include engineering, administration, laboratory and pilot study, construction management and laboratory analysis (see Appendix C).

007829

5.5 Alternative 3: Excavation with Disposal at Off-Site Landfill

This alternative provides for partial excavation of contaminated surface and surficial soil areas and disposal at a nearby off-site landfill.

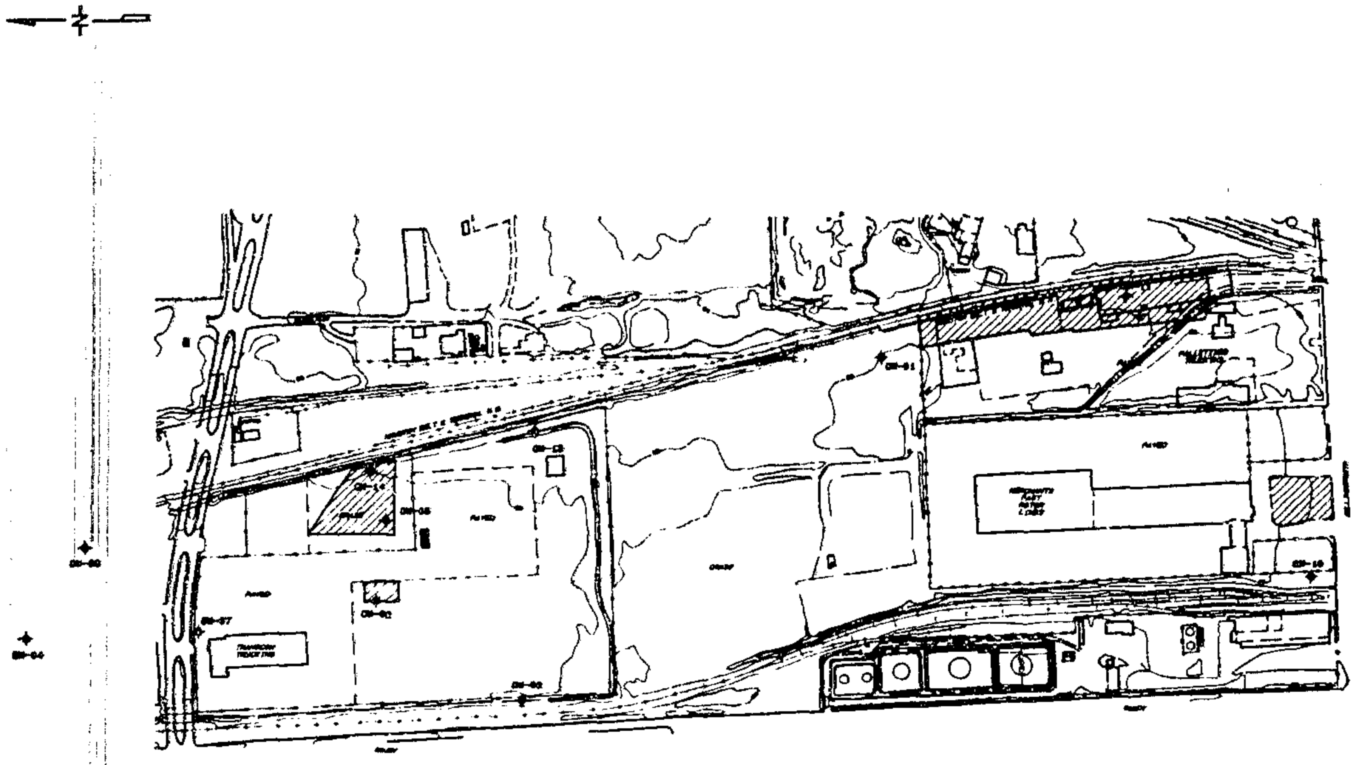
5.5.1 Description

This alternative would include excavating surface and surficial soils suspected of containing organic constituents of concern (PCOCs) from former plant activities. Excavated material, estimated to be 30,000 cubic yards solely for cost estimating purposes, would then be transported to an off-site waste disposal facility. Following excavation, fill material will be placed in the excavated areas, and a minimum of 6 inches of soil cover would be placed on top of the fill material. The areas requiring excavation under this alternative are presented in Figure 5-2.

Excavation of the surface and surficial soils will be achieved using normal excavating equipment. Since the site constituents are not highly mobile, worker safety procedures would be only slightly more than for normal construction. During excavation, hauling and handling of the materials, worker dermal protection and dust control measures should be applied. The estimated 30,000 cubic yards of material will be excavated using normal excavating equipment, such as front-end loaders, hydraulic shovels, and/or backhoes. Loose soils could be excavated employing a tracked front-end loader of about 2 1/2 cubic yards capacity. Based upon an estimate of somewhat difficult conditions and productivity considering worker safety (construction operations will be in strict accordance with related health and safety precautions), the rate of excavation would be about 40 cubic yards per day.

For more "cemented" soils and waste materials, a crawler mounted hydraulic shovel or backhoe of about 1 cubic yard capacity could be employed. This equipment would be employed when the front-end loader's capabilities are exceeded. To break up large oversize pieces, labors may be required to assist the excavation process.

The contaminated soils will be removed and placed in a secure landfill. These materials would be transported to a waste disposal facility and placed in a secure landfill near Houston, Texas. The one way haul distance to this facility is about 150 miles.



LEGEND

APPROXIMATE AREA TO BE EXCAVATED.

KEYSTONE ENVIRONMENTAL RESOURCES, INC

FIGURE 5-2

SOIL EXCAVATION AREAS
SOUTH CAVALCADE, TX

KOPPERS COMPANY, INC.

007831

Over the highway type dump trailers of about 16 cubic yards capacity will be employed. A travel time of about 4 hours would be required for each loaded truck. The transportation would be performed by licensed haulers, and appropriate regulations would be adhered to for the transportation of these type of wastes. About 2,250 13 yd^3 truck loads would be required to transport these waste to the landfill destination. A total of about 337,500 round trip truck miles would be required to transport these materials.

The contaminated soils will be taken to the waste disposal facility permitted to receive and dispose of these materials in a secure landfill. The disposal facility will have appropriate state and federal permits for the disposal of waste materials in a secure landfill.

007832

5.5.2 Compliance with ARARs

This alternative can meet all chemical, action and location-specific ARARs. In the future, this option may not meet land disposal restrictions for CERCLA soil and debris.

5.5.3 Reduction in Toxicity, Mobility or Volume

This alternative would significantly reduce the mobility of PCOCs completely and permanently at the site. The toxicity of the soils disposed at the landfill will not be altered or destroyed in any way, and the volume of the material would not be reduced. The volume could be increased if flyash is added to the soils to bind excess water.

5.5.4 Short-Term Effectiveness

This alternative would meet site remediation goals quickly (37.5 months based on 40 yd^3/day) and result in an immediate removal of the soil exposure pathway to the public. On-site workers conducting remediation activities would possibly be exposed to source material during site restoration. However, potential worker exposures can be reduced if workers follow appropriate health and safety procedures. Additionally, there may be potential emissions from the site during the performance of excavation. The air will need to be monitored, and perhaps the excavation will be enclosed by a temporary dome.

5.5.5 Long-Term Effectiveness

Excavation and off-site landfill disposal would provide a permanent method of remediation for the South Cavalcade, but not at the disposal site. There is always a potential for accidental release of contaminants from a landfill.

5.5.6 Implementability

Excavation and off-site disposal of soils could be accomplished, although there are potential access problems that would need to be overcome at the Palletized Trucking Company. The area by the trucking firm is narrow and confined by adjacent railroad tracks. In addition, there are numerous buildings and structures located within the immediate vicinity of the site access area.

5.5.7 Cost

The total capital cost for the excavation and off-site landfill disposal alternative is about $10,000,000. A summary of the cost breakdown is shown in Table 5-4. There is no operation and maintenance cost associated with the implementation of this alternative; therefore, the present worth is $10,000,000. See Appendix C, Table C-5 for more details in the capital cost breakdown associated with this alternative.

5.5.8 Overall Protection of Human Health and the Environment

Excavation with disposal at an off-site landfill will eliminated all on-site potential exposure pathways since the potential contaminants are removed from the site, thereby reducing the possibility of long term exposure and future site remediation. This alternative will pose minimal potential health and environmental effects to residents and the environment in the vicinity of the site. Residents and the environment in the vicinity of the landfill could undergo potential exposure in the possibility of a landfill failure.

TABLE 5-4

PRESENT WORTH COST SUMMARY FOR

ALTERNATIVE 3

EXCAVATION WITH DISPOSAL AT OFF-SITE LANDFILL

Capital Costs	Costs($)
1. Excavation Costs	240,000
2. Restoration Costs	270,000
3. Hauling Costs	1,350,000
4. Disposal Costs	5,625,000
5. Indirect Costs	516,500
Capital Costs	8,000,000
Contingency Costs (25% of Capital Costs)	2,000,000
Total Capital Costs	10,000,000
Operation and Maintenance Costs	**Costs ($/year)**
none	0
Total O & M Costs	$0
Present Worth ($) @ (10%-30years)	$10,000,000

007834

NOTE: Indirect costs include cost for engineering, administration, construction management and laboratory anaalysis (see Appendix C).

5.6 Alternative 4: Excavation with On-Site Soil Treatment

This alternative deals with partial excavation of highly contaminated areas and on-site soil treatment utilizing either a soil washing process or incineration.

5.6.1 Description

The description of excavation will be identical to that discussed in Section 5.5.1 (description for Alternative 3: Excavation with Off-site Disposal). However, in this alternative the excavated materials will be hauled on-site to one of two on-site soil treatment options. The on-site transportation of soils will be accomplished using dump trucks of about 12 cubic yards capacity. These are commonly available type of trucks with a load capacity of about 20 tons. The collected soils will be processed by one of the following two types of soil treatment methods: 007835

5.6.1.1 Soil Washing

This soil treatment option is a physical separation procedure for detoxifying contaminated soil by washing the contaminants from the soil into a liquid medium. This technique can be carried out in equipment that is designed for contacting excavated soil with liquid. After contact with the soil, the washing solution is treated for removal of the contaminants and then recycled for additional soil washing. In some cases, multiple washings are required to reduce the contaminant concentration to acceptably low levels. The decontaminated soil is typically redeposited in the excavation area after treatment.

Effective detoxification by soil washing requires an understanding of two basic mechanisms by which contaminants are held within a soil environment. One is by chemical adsorption of the contaminant to the surface of the soil particles, and the other involves the retention of contaminant within the interstices of the soil particles. The relative influence of these two mechanisms for retention of the contaminant may vary significantly from site to site depending on several site specific variables. Removal of contaminants from the soil matrix is accomplished by both physical displacement of loosely held contaminants and desorption of contaminants that are more tightly bound to the soil particles.

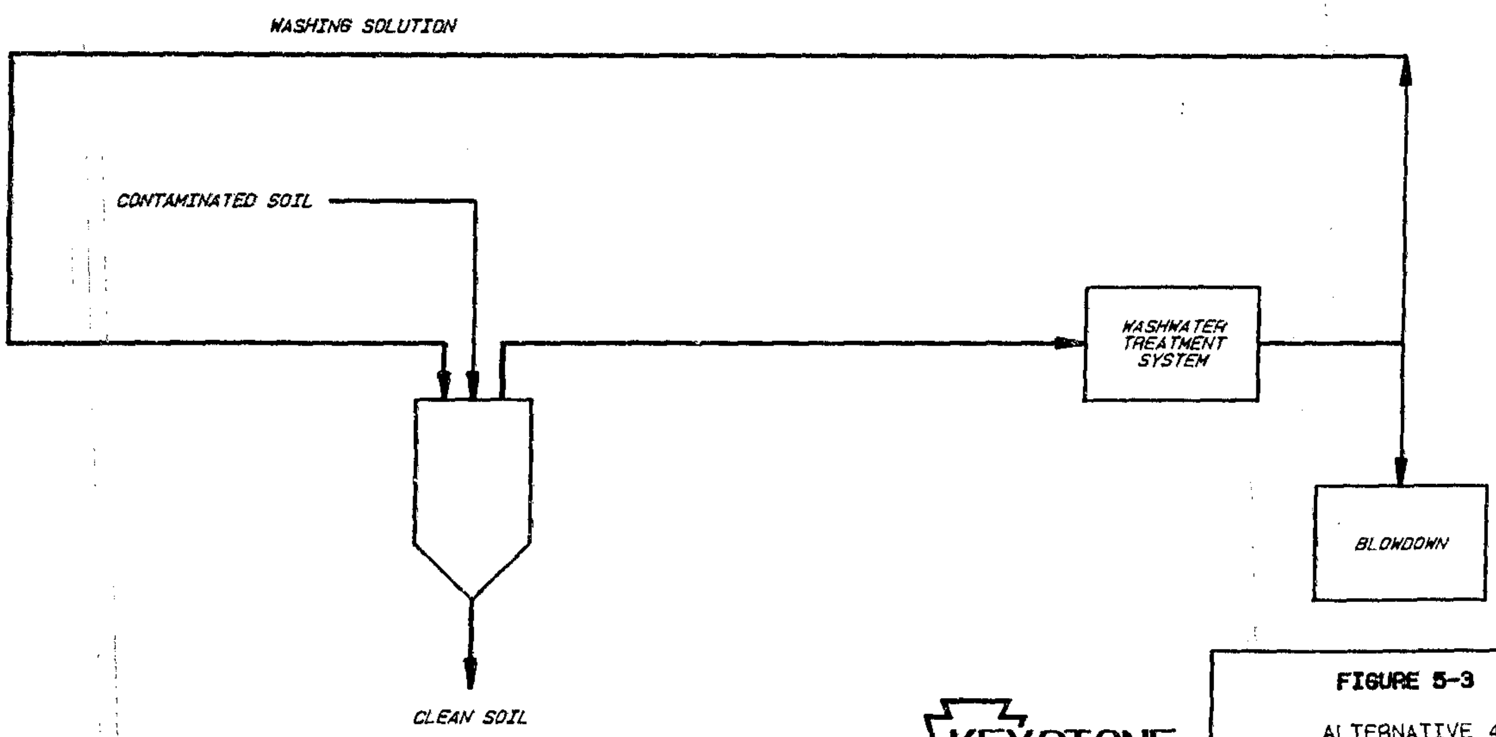
The most important parameters that influence the effectiveness of soil washing are organic content, initial water content, particle size gradation of the soil, and the contaminant type for a given matrix. As contaminants seep into a soil environment, the volume of contaminants that fill or partially fill the soil interstices is a function of the soil particle gradation. The subsequent adsorption of contaminants onto the particles' surfaces is more a function of the soil organic content and surface area. Water that is present in the soil at the time of introduction of the contaminant reduces the pore space available for contaminant migration. The type of contaminant, i.e., whether it is organic or inorganic and properties such as water solubility and density, have a significant impact on the mobility of the contaminants in the soil matrix. Since the above parameters can vary widely at different sites, the type and degree of contaminant retention can also vary significantly. The time required to detoxify the site similarly varies from site to site. The choice of a washing liquid for a particular application is primarily dictated by the contaminant type, the soil matrix, and the degree of difficulty in separating the contaminant from the washing liquid.

Soil washing is a multi-step countercurrent process which will be carried out in an ex situ manner on-site in a system that will be constructed within the central portion of the South Cavalcade site. It has been estimated that it will take approximately 60 months to soil wash 30,000 cubic yards of soil based on a washing rate of 2.5 ton/hour at a duration of 10 hours/day for 20 days/month. Wash waters from the process will be treated in the selected groundwater treatment option (see Alternatives 7 or 8). If no groundwater treatment is felt necessary, these wash waters will have to be treated off-site at an anticipated cost of 34-45 cents/1,000 gallons of wash water.

No vapor recovery system is felt necessary because of the semi-volatile nature of the site contaminant and the fact that volatile compounds can be readily desorbed from the soil matrix into the wash water where treatment will take place. Figure 5-3 presents a schematic representation of the soil washing process.

Laboratory results from a soil washing study presented in section 4.5 of the Treatability Laboratory Report located in Appendix A of this FS study document the removal efficiencies and the optimum surfactant dosage recommended for the site soils.

SOIL WASHING SCHEMATIC DIAGRAM



KEYSTONE ENVIRONMENTAL RESOURCES, INC.

FIGURE 5-3

ALTERNATIVE 4
SOIL WASHING OPTION

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5.6.1.2 Incineration

The equipment used for on-site incineration will consist of a primary oxidation chamber (POC) which heats the contaminated soils to an operating temperature sufficient (1,500^{o} to 2,000^{o}F) sufficient to drive hydrocarbon contaminants from the soils and to initiate the thermal destruction of these contaminants. This incineration equipment will be a rental unit.

Retention time of the soils in the POC, which is established before initiation of the process, is typically 30 minutes. The treated soils fall to a temperature quench zone prior to reincorporation on the site. The exhaust gases from the POC are further oxidized in a secondary chamber. This chamber affords retention time (one to two seconds) and increased temperature (2,000^{o} to 2,200^{o}F) for the complete destruction of the soils volatilized in the POC.

Secondary chamber exhaust is processed through heat exchange to reduce the heat content of this gas stream. Heat may be recovered in the form of steam or preheated combustion air. The cooled gas is treated for particulate matter removal and, where required, acid gases are reduced through a wet scrubbing technology.

The treating capacity of the incineration process would be approximately 50 to 100 tons per day. Actual rating of the unit will be in terms of the heat released with the expected capacity at 40 million BTU per hour. It is estimated to take 23 to 45 months based on the 50 to 100 tons per day rate to incinerate the 30,200 cubic yards of soil at a rental rate of $200/cubic yard.

The expected quality of the incinerator ash will allow the reincorporation of the ash on the site. After incineration and destruction of the constituents in the excavated soils, inert ash may be replaced in the excavated zones of the site. Normally, these types of ashes are inert and non-toxic. The ash will required testing and possibly delisting in order to dispose of it on site. The ash will be tested in accordance with standard EPA toxicity tests to determine if it must be classified as a hazardous waste. If the ash cannot be delisted (must be classified as a hazardous waste) it will require handling and disposal as a hazardous waste, which will result in significantly higher costs than if it were used as fill material.

007838

Transportation, placing and spreading of the inert ash will be accomplished similar to normal earth work practices. The equipment to perform these tasks could be accomplished by 12 cubic yard trucks, medium sized dozers and self-propelled compactors. Since these are very similar to earth moving operations, further discussion of these equipment are presented below.

Soils for backfilling and placing a soil cover over the site will be obtained from the site itself or from within the Houston area at a one-way haul distance of about 30 miles. Over the highway type dump trucks and/or dump trailers will be employed to haul these soil materials to the site at a rate of about 25 tons per load.

Spreading and compaction of the imported soil at the site will be achieved by a medium sized dozer and self-propelled compactor. A sheeps foot drum type compactor has wide flexibility for the types of soils to be compacted and is very productive in compacting soils. These equipment are commonly employed in earthwork and their operation should be similar to normal construction since they operate on the placed, imported, uncontaminated soils.

5.6.2 Compliance with ARARs

5.6.2.1 Soil Washing

This alternative can meet all chemical, action and location-specific ARARs. In the future this option may not meet land disposal restrictions for CERCLA soil and debris.

5.6.2.2 Incineration

All chemical and location ARARs will be met. Action-specific ARARs will be met by designing the alternative according to appropriate federal and state requirements.

5.6.3 Reduction in Toxicity, Mobility or Volume

5.6.3.1 Soil Washing

This alternative would reduce the mobility of PCOCs but maybe not completely. Therefore, continued leaching of site related constituents may be problem. This option will also reduce the toxicity and volume through treatment of the wash water.

5.6.3.2 Incineration

This alternative would result in a permanent reduction in toxicity, mobility and volume of organic PCOCs. However, metals in the soils would not be reduced.

5.6.4 Short-Term Effectiveness

5.6.4.1 Soil Washing

This alternative would meet site remediation goals quickly and result in a quick removal of exposure pathways to the public. On-site workers conducting remediation activities would possibly be exposed to source material during site restoration. However, potential worker exposures can be reduced if workers follow appropriate health and safety procedures. This alternative could result in potential emissions during site excavation work. Therefore, air will need to be monitored and, perhaps the excavation may need to be enclosed in a temporary dome.

5.6.4.2 Incineration

This alternative would provide a quick reduction of PCOCs. On-site workers conducting remediation activities, however, would possibly be exposed to source materials during excavation and handling of soils prior to treatment. Potential worker exposures, specifically during excavation, could be reduced if workers follow appropriate health and safety procedures.

007840

5.6.5 Long-Term Effectiveness

5.6.5.1 Soil Washing

Excavation and on-site treatment by soil washing may not be completely effective because of the possibility of continued low level leaching from the treated soils.

5.6.5.2 Incineration

Excavation and on-site treatment by incineration would provide an effective and permanent approach for managing site soils.

5.6.6 Implementability

5.6.6.1 Soil Washing

On-site soil washing could be accomplished, although there are potential access problems that would need to be overcome at the Palletized Trucking Company. The area to be excavated adjacent to the trucking firm is narrow and access is limited. In addition, buildings and railroad tracks located directly by the potential areas designated for excavation also hinder access.

5.6.6.2 Incineration

If incineration is selected for treating contaminated soils confirmation testing (test burn) may be necessary to evaluate the effectiveness of the system. In addition, testing of the ash (primarily for metal content) will be necessary to determine if the ash can be used as fill or if it has to be disposed of as a hazardous waste. The above tests will take time to implement and complete ,resulting in possible construction delays.

5.6.7 Cost

5.6.7.1 Soil Washing

The total capital cost for the excavation and on-site soil washing alternative is approximately $6,986,000 as presented in Table 5-5a. There is no continued operation and maintenance costs associated with this alternative, therefore, the present worth is also $7,000,000.

5.6.7.2 Incineration

Total capital cost for the excavation and on-site incineration alternative is approximately $10,354,000 as presented in Table 5-5b. There is no continued operation and maintenance costs associated with this alternative, therefore, the total present worth of this option for alternative 4 is $10,400,000.

In Appendix C of this report, Tables C-6 and C-7 detailed cost breakdowns for both options are presented.

5.6.8 Overall Protection of Human Health and the Environment

Excavation with on-site soil treatment will eliminate all on-site potential exposure pathways since the potential contaminants are destroyed or greatly reduced, thereby reducing the possibility of long term exposure and future site remediation. This alternative will pose minimal potential health and environmental effects to residents and the environment in the vicinity of the site.

5.7 Alternative 5: In Situ Treatment

This alternative investigates treatment by one of two types of in-place soil treatment processes. The processes examined include in situ bioreclamation and soil flushing. These alternatives are designed to be implemented concurrently with a groundwater recovery and treatment system.

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TABLE 5-5a

PRESENT WORTH COST SUMMARY FOR

ALTERNATIVE 5

SOIL WASHING TREATMENT OPTION

Capital Cost	Cost ($)
1. Material Handling	810,000
2. Soil Washing Equipment	3,585,000
3. Indirect Costs	1,193,500
Capital Costs	$5,588,500
Contingency Allowance (25% of Capital Costs)	$1,397,000
Total Capital Costs	$6,985,600

Operation and Maintenance Costs	Costs ($/year)
None	0
Total O & M Costs	$0

Present Worth ($) @ (10%-30 years)	$7,000,000

NOTE: Indirect costs include cost for engineering, administration and laboratory analysis (see Appendix C).

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TABLE 5-5b

PRESENT WORTH COST SUMMARY FOR

ALTERNATIVE 4

ON-SITE INCINERATION TREATMENT OPTION

<u>Capital Cost</u>	<u>Cost ($)</u>
1. Material Handling	835,000
2. On-Site Incineration Rental	6,015,000
3. Indirect Costs	<u>1,433,000</u>
Capital Costs	8,283,000
Contingency Cost (25% of Capital Costs	2,071,000
Total Capital Costs	$10,354,000
<u>Operation and Naintenance Costs</u>	<u>Cost ($/ year)</u>
None	0
Total O & M Costs	$0
Present Worth ($) @ (10%-30 years)	$10,400,000

<u>NOTE</u>: Indirect costs include cost for engineering, administration and laboratory analysis (see Appendix C).

007844

5.7.1 Description

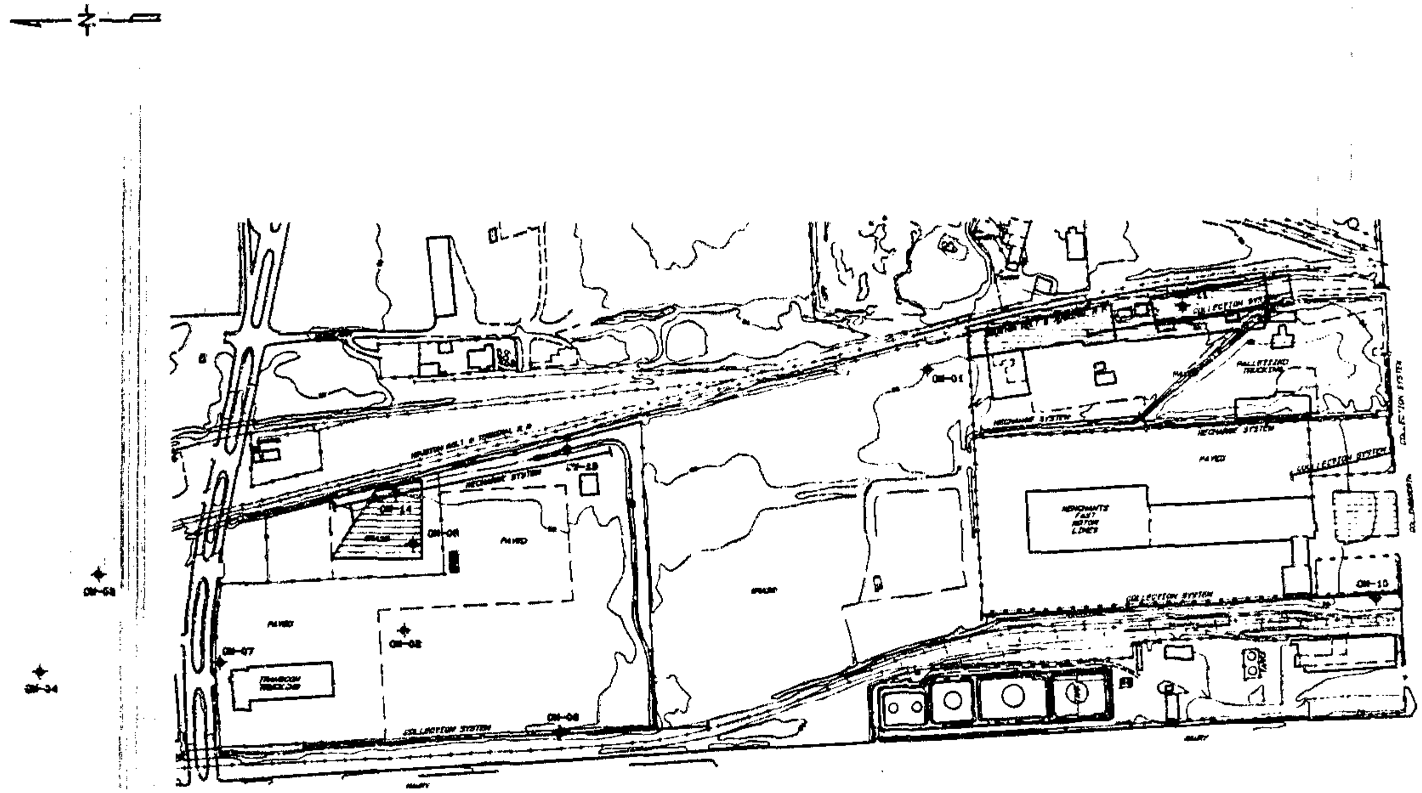
5.7.1.1 Bioreclamation

Bioreclamation is based on the fact that certain organic contaminants are subject to microbial degradation. Indigenous microorganisms can consume certain organic contaminants producing non-hazardous by-products, if environmental conditions are acceptable. The microorganisms degrade only the contaminants which are in solution. Therefore, the design goals for the bioreclamation system are to promote the growth of the in-situ microorganisms and to solubilize the contaminants. In this way, the microbial biodegradation of the contaminants can be enhanced.

The growth of the microorganisms is controlled and limited by conditions in the groundwater environment. Normal microbial activity occurs under anaerobic and aerobic conditions. For in-situ biodegradation, the aerobic microbial process has been most widely developed and appears more feasible (EPA, 1985). The aerobic process involves the addition of oxygen and nutrients to stimulate the growth of the naturally occurring microorganisms. Additionally, surfactants can be added to aid in the desorption of chemical contaminants from soil particles into the water phase, where biodegradation can then occur. Therefore, in order to enhance contaminant degradation the groundwater environment must be altered.

The in situ bioreclamation process for the South Cavalcade site vadose zone soils will treat the contaminated soil through the following steps. Water with appropriate chemical additives will be allowed to percolate through the contaminated soil areas. The enriched water will provide nutrients for the indigenous microorganisms, which will biodegrade the contaminants. The water will eventually flow into the groundwater where any contaminants that remain will be handled by one of the groundwater treatment alternatives.

Figure 5-4 shows the location of the percolation system that will be utilized as part of the in situ bioreclamation process. The percolation system will consist of near surface performated pipe located over the area to saturate the currently unsaturated soil zone.



LEGEND

PERCOLATION PIPE LAYOUT

SCALE (FEET) 0 150 300

KEYSTONE ENVIRONMENTAL RESOURCES, INC.

FIGURE 5-4

BIORECLAMATION PERCOLATION AREAS
SOUTH CAVALCADE, TX

KOPPERS COMPANY, INC.

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5.7.1.2 Soil Flushing

In situ soil flushing is a chemical-physical process of extracting contaminants from the soil matrix. A water solution, containing surfacants or other chemicals, is continuously passed through the contaminated soil zone dissolving the contaminants. Once in solution, the contaminants are free to move out of the contaminated soil zone. The contaminants will in effect be leached from the soil zone and travel into the groundwater. The contaminants which travel into the groundwater will be handled by one of the groundwater treatment alternatives. The treatment areas and method are basically the same as for the bioreclamation alternative, see Section 5.7.1.1.

007847

5.7.2 Compliance with ARARs

Both of the technologies that could potentially be used for in-place soil treatment would meet chemical and location-specific ARARs. The action-specific ARARs could also be met by designing the alternatives according to the appropriate requirements.

5.7.3 Reduction in Toxicity, Mobility or Volume

In situ bioreclamation and soil flushing would significantly and permanently reduce toxicity, mobility and volume of site related soil compounds. Some mobility of the site related compounds could potentially occur for any material left in place following treatment. The actual reduction of toxicity and volume of PCOCs will take place in the groundwater treatment system.

5.7.4 Short-Term Effectiveness

This alternative would not meet site remediation goals quickly because in situ processes require a long time for completion. This alternative would be anticipated to require several years to complete. On-site workers conducting remediation activities would possibly be exposed to source material during site restoration but to a lesser degree than for excavation. However, potential worker exposures can be reduced if workers follow appropriate health and safety procedures.

5.7.5 Long-Term Effectiveness

The use of either bioreclamation or soil flushing would provide a permanent method for restoring the South Cavalcade site after completion. However, they may result in groundwater contaminants being pushed off-site at the Palletized Trucking Company because the additional water may change the local hydraulic gradient to slope to the east and force creosote in the aquifer off-site.

5.7.6 Implementability

Either in situ bioreclamation or soil flushing could be accomplished. If either of these technologies are selected it may be necessary to perform pilot or laboratory-scale testing to evaluate operation parameters associated with the design of the technologies.

5.7.7 Cost

5.7.7.1 Bioreclamation Cost

Bioreclamation must be considered concurrently with a groundwater recovery and treatment system (See cost estimate for Alternative 7). The only capital expenditure for this alternative would be materials and construction costs for the installation of a surface piping system located in the two areas of contamination. The present worth for this treatment option is estimated at $530,000 as presented in Table 5-6a. Detailed breakdown of this analysis is presented in Appendix C, Table C-8 and C-9.

5.7.7.2 Soil Flushing

As with the cost estimate for in situ bioreclamation this alternative must be considered concurrently with a groundwater recovery and treatment system (See cost estimate for Alternative 8). The only capital expenditure for this alternative would be the installation of the surface piping system. The present worth for the treatment system is estimated at $530,000 and is presented in Table 5-6b. Detailed breakdown for this cost estimate is presented in Appendix C, Table C-10 and C-11.

007848

TABLE 5-6a

PRESENT WORTH COST SUMMARY FOR

ALTERNATIVE 5

BIORECLAMATION SOIL TREATMENT OPTION

Capital Cost		Cost ($)
1.	Excavation cost	1,500
2.	Pipe installation cost	116,800
3.	Disposal cost	10,600
4.	Hauling	3,000
5.	Repair	16,000
6.	Indirect cost	238,500
	Capital Costs	$386,400
	Contingency Cost (25% of Capital Costs	$96,600
Total Capital Costs		$483,000

Operation and Maintanence Cost	Costs ($/year)
1.Miscellaneous (fence, percolation pipe)	5,000
Total O & M Costs	$5,000

Present Worth ($) @ (10%-30 year)	$530,000

NOTE: Indirect cost includes cost for engineering, administration, construction management, laboratory analysis and pilot study (see Appendix C).

007849

TABLE 5-6b

PRESENT WORTH COST SUMMARY FOR

ALTERNATIVE 5

SOIL FLUSHING SOIL TREATMENT OPTION

Capital Cost		Cost ($)
1.	Excavation cost	1,500
2.	Pipe installation cost	116,800
3.	Disposal cost	10,600
4.	Hauling	3,000
5.	Repair	16,000
6.	Indirect cost	238,500
	Capital Costs	$386,400
	Contingency Cost (25% of Capital Costs	$96,600
Total Capital Costs		$483,000

Operation and Maintanence Cost		Costs ($/year)
1.	Miscellaneous (fence, percolation pipe)	5,000
	Total O & M Costs	$5,000
Present Worth ($) @ (10%-30 year)		$530,000

NOTE: Indirect cost includes cost for engineering, administration, construction management, laboratory analysis and pilot study (see Appendix C).

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5.7.8 Overall Protection of Human Health and the Environment

In situ soil treatment will eliminated all on-site potential exposure pathways since the potential contaminants are destroyed or greatly reduced, thereby reducing the possibility of long term exposure and future site remediation. This alternative will pose minimal potential health and environmental effects to residents and the environment in the vicinity of the site.

5.8 Alternative 6: Excavation and Off-Site Incineration Treatment

Alternative 6 provides for partial removal of contaminated hot spots with off-site incineration of soils.

5.8.1 Description

The partial excavation and off-site transportation process will be identical to that described in Section 5.5.1 under Alternative 3. However, prior to loading the excavated soils for transportation to the off-site incineration facility, the soils will be containerized in 20-gallon plastic containers. This is a requirement of the off-site incinerator facility.

The nearest off-site incineration facility capable of handling the PCOCs in the soils is located in Deer Park, Texas. This facility is approximately 20 miles away from the South Cavalcade site.

Flat bed trailers will be used to haul the 20-gallon plastic containers to the off-site incineration facility. It is anticipated that approximately 2300 trips based on 13 yd^3 trucks will be necessary to complete the process. The processing rate is estimated at 15 cubic yards/day. The transportation will be performed by licensed haulers and appropriate regulations will be adhered to for the transportation of these types of wastes.

5.8.2 Compliance with ARARs

Off-site incineration would meet chemical and location-specific ARARs. Action specific ARARs would be meet by using a incinerator facility compliant with their RCRA permit.

5.8.3 Reduction in Toxicity, Mobility or Volume

This alternative would result in a permanent reduction in toxicity, mobility and volume for organics. However, metals in soils would not be reduced.

5.8.4 Short-Term Effectiveness

This alternative would take approximately 66 months to reduce the PCOCs. On-site workers conducting remediation activities, however, would possibly be exposed to source materials during excavation and handling of soils prior to treatment. Potential worker exposures, during the excavation process, could be reduced if workers follow appropriate health and safety procedures.

5.8.5 Long-Term Effectiveness

Excavation and off-site incineration treatment would provide an effective and permanent approach for managing site soils.

5.8.6 Implementability

Treatment of soils by this alternative could be accomplished, although there are potential access problems that would need to be overcome at the Palletized Trucking Company for the excavation of soils. Excavation will be hindered due to the narrow passageway for truck access and confinement by the adjacent railroad tracks and buildings. In addition, if off-site incineration is selected for treating contaminated soils confirmation testing (test burn) will be necessary to evaluate the effectiveness of the incinerator system in destroying the wastes. Also testing of the ash will have to be performed to verify whether it is listed as a hazardous wastes or not. These procedures will require time and may delay the remediation process.

5.8.7 Cost

The total capital cost for the excavation and off-site incineration alternative is about $62,055,000. The cost breakdown is shown in Table 5-7. There is no operation and maintenance cost associated with the implementation of this alternative, therefore, the present worth is $62,000,000. Details of the cost estimate are presented in Appendix C, Table C-12.

5.8.8 Overall Protection of Human Health and the Environment

Excavation with off-site incineration will eliminated all on-site potential exposure pathways since the potential contaminants are destroyed, thereby reducing the possibility of long term exposure and future site remediation. This alternative will pose minimal potential health and environmental effects to residents and the environment in the vicinity of the site.

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GROUNDWATER ALTERNATIVES

5.9 Alternative 7: Groundwater Collection and Aquifer Treatment (Bioreclamation) with Physical/Chemical Separation Followed by Disposal

Alternative 7 was developed to offer a method of in situ groundwater treatment utilizing subsurface bioreclamation and on-site physical/chemical separation followed by discharge of a portion of the treated waters.

5.9.1 Description

In situ bioreclamation will provide a mechanism for accelerating the natural degradation of organic contaminants. Physical/chemical separation will provide treatment for toxic metals and non-aqueous phase liquids (NAPLs). This in situ process and its associated above groundwater treatment system will not provide treatment for volatile organic compounds.

To remove contaminated groundwater from the aquifer (estimated volume requiring remediation is 50 million gallons) prior to subsequent treatment, groundwater will be

TABLE 5-7

PRESENT WORTH COST SUMMARY FOR

ALTERNATIVE 6

EXCAVATION WITH OFF-SITE INCINERATION

Capital Cost	Cost ($)
1. Excavation Costs	240,000
2. Restoration Costs	270,000
3. Hauling Costs	230,000
4. Incineration Costs	45,000,000
5. Indirect Costs	3,903,500
Capital Costs	49,643,500
Contingency Cost (25% of Captial Costs	12,411,000
Total Captial Cost	$62,055,000
Operation and Maintanence Cost	**Costs ($/year)**
None	0
Total O & M Costs	$0
Present Worth ($) @ (10%-30 year)	$62,000,000

NOTE: Indirect cost includes cost for engineering, administration and laboratory analysis (see Appendix C).

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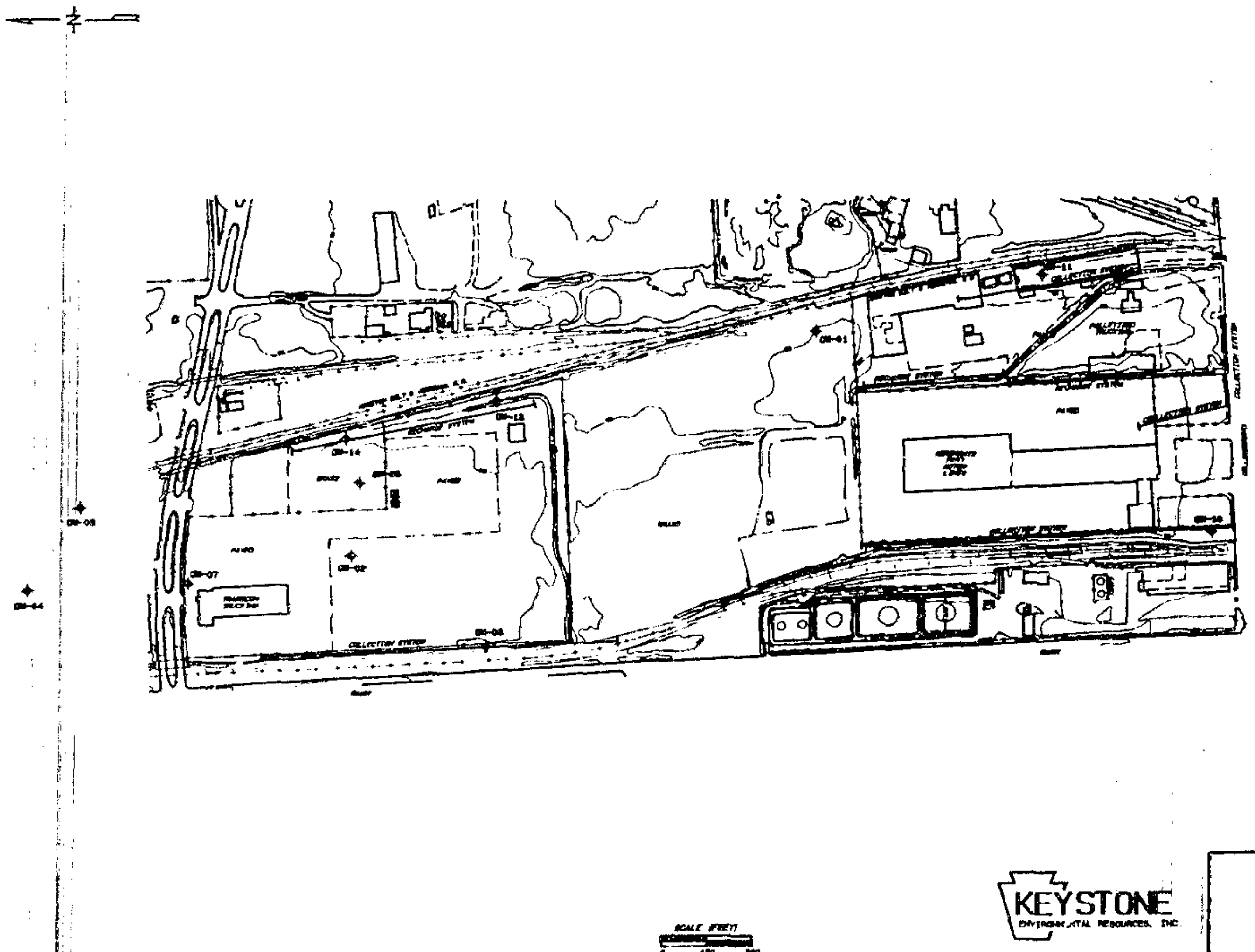
collected and reinjected via a series of pumping reinjection wells and well points. These wells will act as both a line sink and line source, and will recover the shallow and intermediate zone contaminated groundwater. Recharge wells would be used to increase the hydraulic gradient and thus increase the flow rate through the aquifer, and to dispose of the treated water. As shown on Figure 5-5A, the groundwater collection/reinjection system would consist of three separate collection lines (groundwater sinks) and two recharge lines (sources). One collection system would be located in the southeast corner of the property, and is intended to collect contaminant migration from the former coal tar operation. This collector well system would be approximately 600 feet and consist of 15 pumping wells, each sustaining a rate of 1.5 gallons per minute. West and downgradient from this line of pumping wells would be two lines of reinjection wells, each with a similar injection well spacing of approximately 50 feet. The actual necessity for the reinjection wells on the northern portion separating Palletized Trucking and Merchants Fast Motor Lines will be determined during the Remedial Design phase. The second collection well system would be immediately downgradient from the reinjection wells and along the southern boundary, located such that it intercepted contaminant migration from the former wood treating operations and a portion of the reinjected water. In addition, this collection system is designed to prevent contaminant migration from the southern portion of the site. This pumping well system would consist of 16 pumping centers at approximately a 40-foot spacing interval, for a total collection distance of 600-feet. The final line of groundwater pumping wells would be located along the southwestern property boundary, and would be similar in design to the two other collection systems. This pumping center would be approximately 1000-feet long, and would intercept groundwater prior to leaving the South Cavalcade site. Twenty-five pumping wells would be used to collect this portion of the groundwater system.

In the northern section of the facility, groundwater will be collected and reinjected via a series of pumping wells and reinjection wells as presented in Figure 5-5A. The collection system will be approximately 1200 feet in length with 60 pumping well centers at 20-foot spacings. Each pumping well will be designed to sustain a pumping rate of 1.5 gallons per minute. The reinjection system located east and upgradient from the line of collection wells will consist of a line of reinjection wells, with a well spacing of 20 feet for a total distance of 825 feet.



KEYSTONE
ENVIRONMENTAL RESOURCES, INC.

FIGURE 5-5A

GROUNDWATER COLLECTION/
RE-INJECTION SYSTEM
SOUTH CAVALCADE, TX

KOPPERS COMPANY, INC.

The groundwater will be pumped from the trench/drain collection system and will be treated in a two stage gravity separation process for non-aqueous phase liquids (NAPLs) recovery. The water would first pass through one of two equalization tanks (approximately 5,000 gallons each) operated as batch units, and then through an API separator unit. The pre-separation step would be designed to provide gravity removal of the majority of non-aqueous phase liquids (NAPLs) present in the groundwater, while the API separator unit would include provisions for polymer addition and pH adjustment (if needed) to remove residual and emulsified (NAPLs) that passed through pre-separation. The groundwater would flow by gravity through both stages of the physical/chemical separation system. Recovered (NAPLs) from the pre-separation step and API separator will be pumped to a dehydrator unit where the (NAPLs) will be thickened prior to disposal. A portion of the effluent from the physical/chemical separation system will flow by gravity to a nutrient tank where appropriate additives will be dissolved into the waters. Appropriate additives include oxygen and nutrients to promote microorganism growth, along with surfactants to help release the contaminants from the soil particles. Figure 5-5B presents a schematic of the groundwater treatment system. The treated water will then be re-injected into the shallow groundwater system to increase the local hydraulic gradient, and thus provide an increased cyclic flushing of the subsurface contaminants within the soils, resulting in additional solubilization of the contaminants. Once in solution, the contaminants will be available for biodegradation and free to be removed by the collection wells.

The remaining portion of water not re-injected will be discharged to the City of Houston POTW. This method of disposal will require that an effluent monitoring station and related piping be installed to connect the groundwater treatment system. The effluent monitoring station will be equipped with both pH and flow monitoring instrumentation, and related equipment. Additionally, a small laboratory facility may be required at the site for the treatment plant operator to perform any necessary routine monitoring that may be required for operating the treatment system.

5.9.2 Compliance With ARARs

The chemical and location specific ARARs identified in section 3.0 of this feasibility study will be meet. Action specific ARARs can be meet because the alternative will

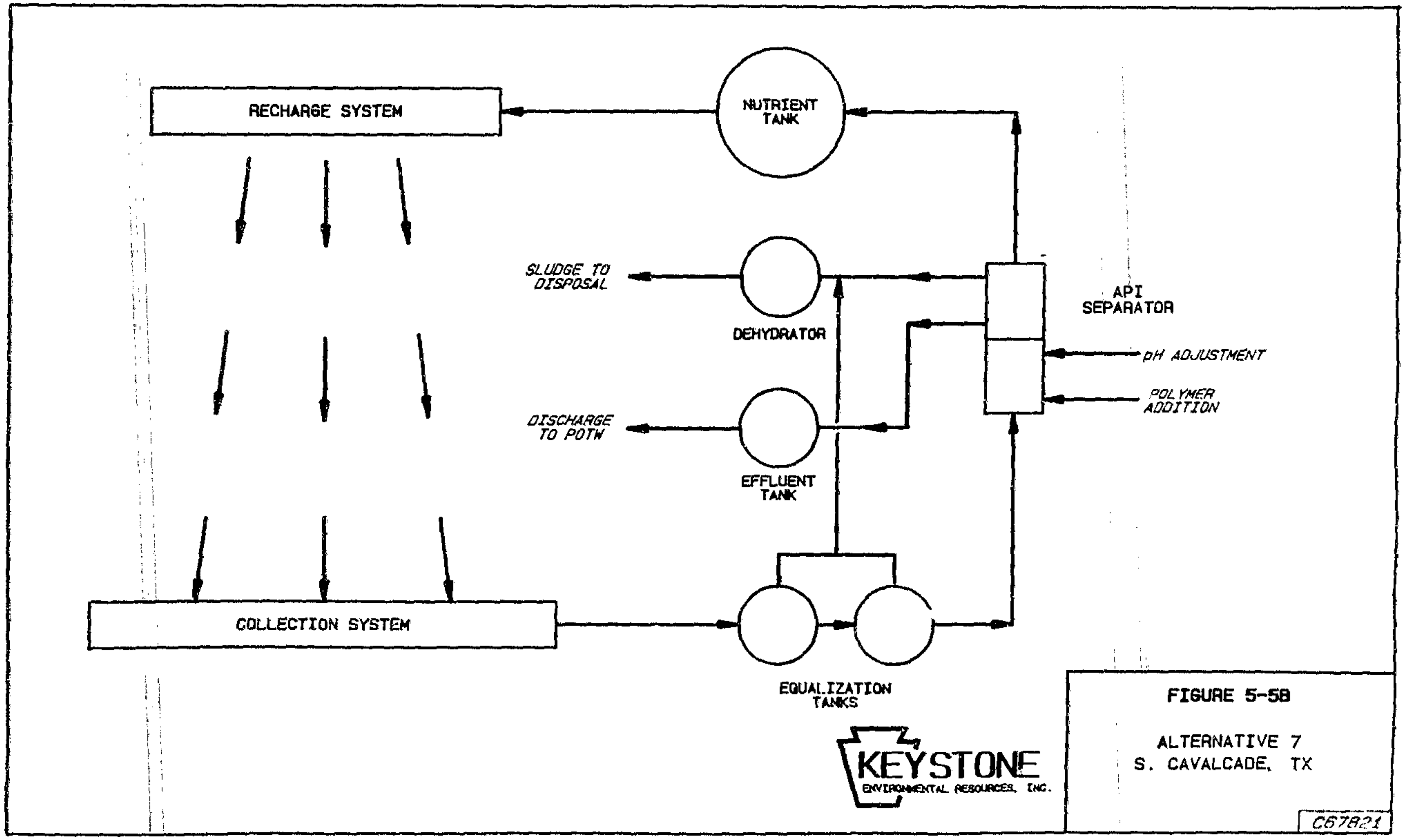


FIGURE 5-5B

ALTERNATIVE 7
S. CAVALCADE, TX

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be designed to meet all action specific ARARs. If the city decides to strictly enforce its prohibition on indirect discharges of priority pollutants, or if the city adds new restrictions, then the discharge to the city may not meet the terms of the city's pretreatment permit with EPA.

5.9.3 Reduction of Toxicity, Mobility or Volume

This alternative would result in a significant reduction of toxicity, mobility and volume of organic contaminants by converting them to water and carbon dioxide. In addition, the physical/chemical separation process would result in a significant reduction in the concentration of metals in the groundwater. As a result of the implementation of this alternative, most of the organic contaminants would be permanently eliminated; however, there exists a possibility that some of the contaminants may not be completely destroyed in the early stages of the process. Therefore, some mobility for migration exists.

5.9.4 Short-Term Effectiveness

This alternative would result in almost complete removal of contaminants through the groundwater. There would exist a small chance for worker exposure during start-up and construction of the above ground treatment process.

5.9.5 Long-Term Effectiveness

The treatability report located in Appendix A of this feasibility study presents evidence showing that polymer treatment and physical separation are effective in the removal of NAPL's and Total PAH compounds from the site contaminated groundwater. Table 5-8a, which has been extracted from the treatability report, summarizes the results of the oil/water separation study. As can be seen from the Table, NAPL's concentrations were reduced by 86.2% and Total PAH compounds by 73.1% just with physical separation alone. The final effluent concentration after physical separation were recorded as 19.9 mg/l NAPL's and 10.5 mg/l Total PAH. Correspondingly, results of the in situ soil bioreclamation experiment conducted as part of the treatability study indicate that approximately 72% of Total PAH compounds were biodegraded within an eight week period. These results are presented in Table 5-8b. It is anticipated that even greater removal efficiencies can

TABLE 5-8a

COMPARISON OF POLYMER TREATMENT VERSUS PHYSICAL SEPARATION
(RESULTS IN MG/L)

	MSTC Raw Composite Sample 12/10/87	Polymer Treated Supernatent Sample 12/31/87	% Removal (from raw water)	Physical Separation Sample 12/14/87	% Removal (from raw water)
Methylene Chloride Extractables	253	54	78.7	75.0	70.4
Oil and Grease	144	13.6	90.6	19.9	86.2
Total Organic Carbon	59.8	59.6	0.3	60.5	(*)
Phenolics (4AAP)	7.82	-	-	7.72	1.3
Total PAH(1)	39.225	-	-	10.538	73.1

(1)Total PAH represents total polynuclear aromatic hydrocarbons.
(*)Indicates that parameter has increased in concentration.

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TABLE 5-8b

SOIL COLUMN STUDY
GROUNDWATER INFLUENT RESULT

Conventional Pollutants (mg/l)	Initial Influent Sample (1/11/88)	Initial Influent Sample (3/3/88)
BOD	42.0	240
COD	240	178
Oil and Grease	20.8	26.3
Phenols (4AAP)	5.70	3.47
TKN as N	8.80	7.35
TOC	56.7	52.6
Total PO_4	6.95	6.10
pH (units)	7.5	7.6
Total Detectable Metals (ug/l)		
Arsenic	12.7	--
Individual PAH (ug/l)		
Carbazole	304	28.1
Naphthalene	2700	739
Acenaphthene	352	146
Acenaphthylene	178	87.8
Anthracene	30.5	8.97
Fluorene	189	55.9
Phenanthrene	288	76.9
Benzo(a)anthracene	13.1	4.60
Chrysene	10.8	3.54
Fluoranthene	83.5	25.3
Pyrene	83.8	20.6
Benzo(k)fluoranthene	1.03	0.483
Benzo(a)pyrene	1.68	0.841
Benzo(b)fluoranthene	2.90	1.32
Dibenz(a,h)anthracene	1.65	1.10
Indeno(1,2,3-c,d)pyrene	0.766	0.355
Benzo(g,h,i)perylene	1.62	0.630
TOTAL PAH (%) REMOVAL	71.6	

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be achieved through in situ bioreclamation over the longer period of time during remediation.

In situ bioreclamation with the above groundwater treatment system is expected to provide permanent effectiveness for remediation of the groundwater at the site.

5.9.6 Implementability

The construction of the facilities associated with the bioreclamation alternative can be implemented at the South Cavalcade Site. Materials and equipment required to implement this alternative are readily available. The well borings and pipe trenches required for the groundwater collection and recharge system involve ordinary construction practices. The only potential construction difficulty will be locating the facilities to avoid site utilities, concrete capped areas, buildings, highways, and the railroad tracks bounding the site. Adequate design information must be obtained to satisfactorily locate the bioreclamation facilities. Based on current data, the construction should not be prohibited by site conditions.

The operational reliability of the bioreclamation system depends on its components. The wells and piping systems are reliable methods of collecting and conveying the groundwater. The results of a treatability study performed by Keystone, using contaminated soils from the site, have shown that bioreclamation should work in reducing the organic contaminants in the groundwaters to acceptable limits for discharge to the City of Houston POTW. At present the City of Houston has general policy that no priority pollutants will be accepted. As benzene and PAH are both priority pollutants, the required levels of removal for these pollutants will have to be discussed individually with the City of Houston. For the City of Houston to accept any discharge from the South Cavalcade site, a determination will have to be made by the City on the available capacity of the wastewater treatment plant as well as nearby sewer lines. The treated groundwaters will only be accepted if capacity is determined to be available in both the collection and treatments systems. The above conditions will require time to investigate and finalize. These political matters could delay the remediation process. Additionally, there are potentially more restrictive requirements which may be added in the future which would necessitate revisions to the groundwater treatment system.

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During construction of the wells and pipe trenches, contaminated soils may be recovered. The solid wastes will be disposed of at an approved hazardous waste disposal facility or with the soil remediation alternative, if it is practical. Operation of the water treatment plant may produce limited quantities of waste for disposal. Adequate disposal facilities are available near the site and can handle the types and quantities of waste generated during the implementation of the bioreclamation alternative.

The installation of this alternative may be difficult because all locations of the proposed collection and re-injection trenches are not easily accessible. Some areas are presently covered by concrete. Others cross roads used by on-site trucking firms. In addition, it will be necessary to cross the railroad tracks to construct the southeastern re-injection system. This may not be feasible because of the railroad's right of-way. These obstructions can cause problems during design.

Construction of the wells and associated piping will take about 4 months to complete. The water treatment plant can be constructed and operational in an additional 7 months. The concrete cap can be constructed concurrently with the other activities. The total remediation of the site cannot be predicted at this time; therefore, 30 years was used as an estimate.

5.9.7 Cost

The total present worth cost for the bioreclamation alternative is $6,500,000, assuming 10% interest and 30 year monitoring and remediation period. The summary of the cost breakdown is shown in Table 5-8c. The cost estimate is based on Keystone's judgement for the system costs with reference to Mean's Facilities Cost Data and guidance provided by the EPA "Remedial Action at Waste Disposal Sites" document. The groundwater treatment system costs are based on Keystone's in-house data and experience in the waste water treatment industry. A 25% contingency has been applied to the costs due to the conceptual nature of the system design elements. In addition, the costs could be higher if additional treatment is needed to comply with more stringent permit limits imposed by the city. This increase would be similar to the costs of the other groundwater alternatives.

TABLE 5-8c

PRESENT WORTH COST SUMMARY FOR

ALTERNATIVE 7

GROUNDWATER COLLECTION WITH IN SITU TREATMENT AND PHYSICAL/CHEMICAL SEPARATION FOLLOWED BY DISPOSAL

Capital Cost	Cost ($)
1. Collection and Recharge Systems	2,221,100
2. Oil/Water Separation System Direct Costs	486,500
3. Oil/Water Separation System Indirect Costs	66,000
4. Health and Safety Requirements During Construction	16,000
5. State and Local Fees	5,000
Capital Costs	2,800,000
Contingency allowances (25% of Capital Costs)	700,000
Total Capital Costs	3,500,000

Operation and Maintenance Costs	Costs ($/year)
1. Chemicals	53,000
2. Electricity Requirements	4,000
3. Sludge Disposal	33,750
4. Man Power	151,840
5. Sampling and Analyses	71,750
6. Maintenance (2% of Oil/Water Separation System Direct and Indirect Costs)	10,850
Total O & M Costs	$325,190
Present Worth ($) @ (10%-30 years)	$ 6,500,000

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A detailed breakdown of the capital and annual operating costs for alternative 7, as summarized in Table 5-8c, has been included in Appendix C (See Tables C-13 and C-14).

5.9.8 Overall Protection of Human Health and the Environment

This alternative will greatly reduce the concentrations of PCOCs in the groundwater, thereby reducing the possibility of long term exposure and future site remediation. This alternative will pose minimal potential health and environmental effects to residents and the environment in the vicinity of the site.

5.10 Alternative 8: Groundwater Collection and Aquifer Treatment (Soil Flushing) with On Site Groundwater Treatment followed by Disposal

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This Alternative involves the use of an in situ treatment process, soil flushing and three on site groundwater treatment options: (1) Physical/Chemical Separation followed by Granular Media Filtration and Activated Carbon Treatment, (2) Physical/Chemical Separation followed by Granular Media Filtration with Air Stripping and Activated Carbon Treatment and (3) Physical/Chemical Separation followed by Aeration Tank Biological Treatment.

5.10.1 Description

The physical facilities for extracting and reinjecting the groundwater are the same as for the bioreclamation alternative. A discussion of the facilities can be found in Section 5.9.1. Three water treatment options will be considered for the soil flushing alternative. A description of each option is presented below.

5.10.1.1 Groundwater Treatment Option 1 Physical/Chemical Separation Followed by Granular Media Filtration and Activated Carbon Treatment

This groundwater treatment option will consist of a two stage gravity separation process for (NAPL) recovery followed by suspended solids and metal filtration and an activated carbon unit for organic contaminant removal. The two stage gravity separation process will be identical to the groundwater treatment process described in Section 5.9.1 (Alternative 7). Following the (NAPL) recovery process a portion of the groundwater will be pumped through a pressure filter. This step in the treatment process will be performed to remove possible arsenic and other metal contaminants and suspended matter that would cause operational problems and decrease efficiencies in the activated carbon unit. The filter would most likely be a multimedia type pressure filter that would incorporate the use of two skid mounted filters. The unit would be fully automated. One filter would normally be in operation. The alternate filter would become the operating filter when the other one requires backwashing and this cycle would continue between the filters. A relatively high rate backwash pump capable of pumping approximately 100 gallons per minute will be required to properly backwash the filtering media. Backwash water will be supplied from one of the 5,000 gallon equalization tanks with discharge to a separate backwash tank with an approximate capacity of 4,000 gallons. A 5 gallon per minute pump will return the supernatant from the backwash tank to the equalization tank. Periodic solids removal from the backwash tank will be required. Water from the filtration unit will flow to one of two skid mounted carbon adsorption units containing approximately 6,500 pounds of carbon per unit with one unit serving as a spare during carbon replacement. Each carbon unit will be constructed of carbon steel with a conical bottom and lined with epoxy, or equivalent lining. The carbon units will be equipped with underdrains and related piping for carbon filing and spent carbon discharge. Based on preliminary laboratory testing (see Appendix 9A of the Treatability Laboratory Report in Appendix A of this feasibility report) the estimated annual carbon consumption used for costing purposes is 200 pounds per day. The predicted annual usage at the above consumption rate equals about 70,000 pounds. This carbon usage is based on treating an average flowrate of 50 gallon per minute.

Excess treated effluent from the carbon adsorption unit will be discharged to the adjacent drainage which flows into Hunting Bayou. Most of the effluent will be re-injected because the continuous pumping and re-injection will create a hydraulic barrier around the treatment zone allowing only a small quantity of the continued groundwater flow to enter the region.

Discharging to the adjacent stream will require an NPDES permit. The primary components associated with discharging treated groundwater into the Hunting Bayou will include installing an effluent monitoring station and piping from the final treatment unit to the discharge outfall. The effluent monitoring station will be equipped with both pH and flow monitoring instrumentation, and related sampling equipment.

Additionally, a small laboratory facility will be required at the site in order for the treatment plant operator to perform any necessary routine monitoring that may be required for operating the treatment system. Figure 5-6A presents a schematic flow diagram showing major pieces of equipment associated with Alternative 3 (Groundwater treatment option 1 - Physical/chemical separation followed by granular media filtration and activated carbon treatment).

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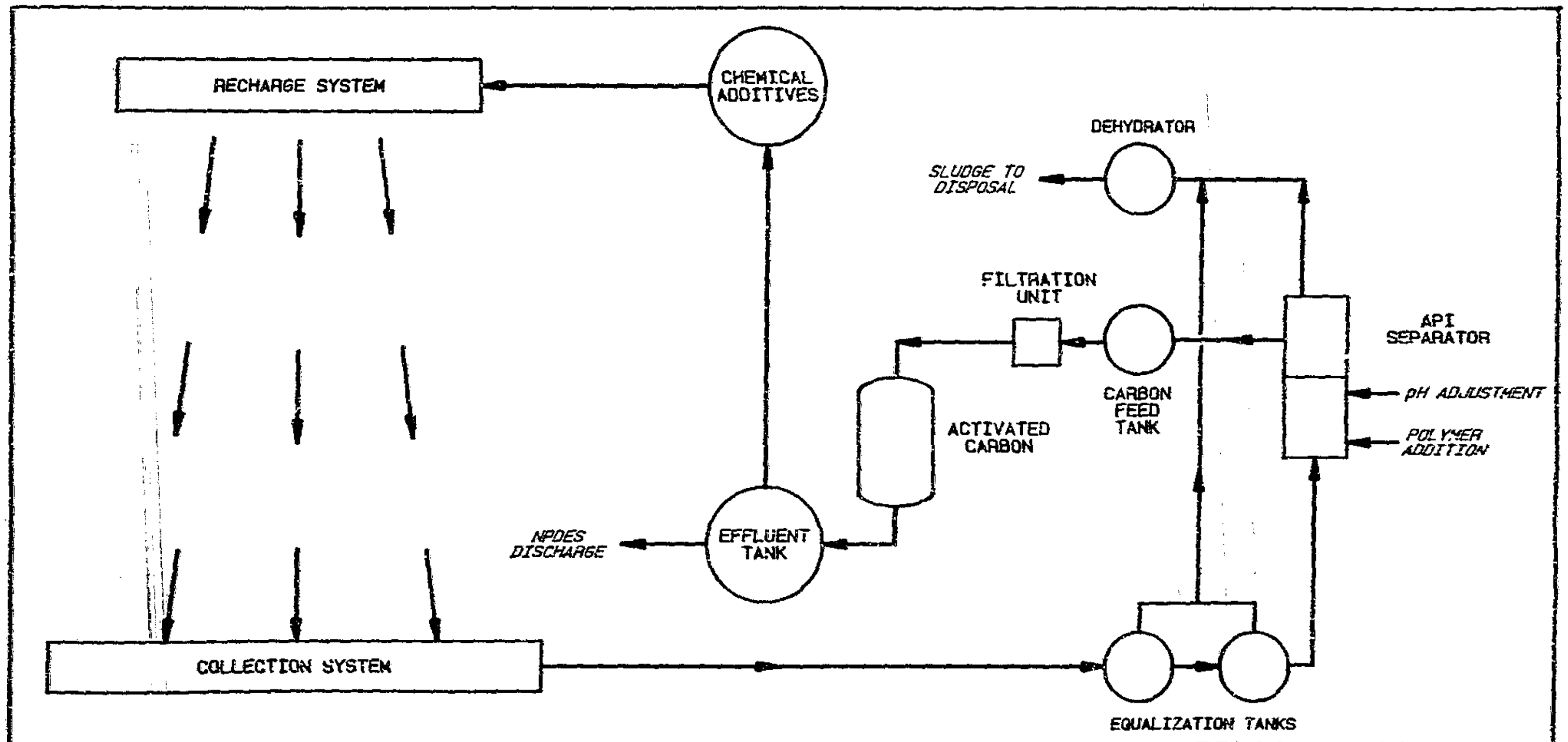
5.10.1.2 Groundwater Treatment Option 2 Physical/Chemical Separation followed by Granular Media Filtration with Air Stripping and Activated Carbon Treatment

This groundwater treatment option will be identical to the above option (Section 5.10.1.1) except for the addition of an air stripping column. The air stripping column will be located directly after the filtration unit and before the carbon adsorption unit. Recent analyses indicates that volatile organics may be present in higher concentrations than previously anticipated, therefore, in order to decrease the carbon usage rate an air stripper has been recommended.

The air stripping unit will be in the form of an aeration column (tower). It is estimated that the tower will have a diameter of approximately 2 feet and a packing height of approximately 15 feet. An air blower will be required to transport air through the column. It may be necessary to install an a vapor recompression unit to process the organic vapors from the top of the air stripping column. Because of the uncertainty as to the volatile organics concentration in the groundwaters, this was not included in the capital cost estimate. Final design and engineering considerations will have to be made in order to specify the proper unit (if needed) for fabrication.



KEYSTONE
ENVIRONMENTAL RESOURCES, INC.

FIGURE 5-6A

ALTERNATIVE 8
GROUNDWATER TREATMENT OPTION 1
S. CAVALCADE, TX

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With the addition of an air stripping column the estimated carbon usage rate will be reduced. The exact reduction afforded has not been determined; however, it is assumed that the carbon usage can be reduced by at least 10 %. This would result in a carbon rate of approximately 180 pounds per day or 63,000 pounds per year. Figure 5-6B presents a schematic representation of Alternative 8 (Groundwater treatment option 2 -Oil/water separation followed by granular media filtration with air stripping and activated carbon treatment).

5.10.1.3 Groundwater Treatment Option 3 Physical/Chemical Separation followed by Activated Sludge Biological Treatment

Physical/chemical separation under this groundwater treatment option is identical to the above two options under Alternative 8 (see Sections 5.10.1.1 and 5.10.1.2). In addition to physical/chemical separation this treatment option will utilize an aerobic biological treatment system (activated sludge) to remove organic contaminants. Following the physical/chemical separation process, the groundwater will be pumped through the activated sludge system. The water will be pumped to an aeration tank and then by gravity will flow through a clarifier. The major components of the activated sludge system are the aeration tank in which bacteriological action will degrade the constituents of concern and a clarifier which serves to settle and remove biological sludge that forms as a result of the activity in the aeration tank. Sludge from the clarifier will be recycled back to the aeration tank and a lesser volume will be periodically wasted and disposed off-site. Accessories to the aeration tank will include a submerged aerator, pH adjustment system, compressed air system (two blowers), and a nutrient addition system. All of these components are required to provide and ensure acceptable conditions for bacterial growth. Clarifier accessories will include a mechanical sludge rake mechanism and sludge recycle pumps to facilitate sludge removal and transfer.

Based on the groundwater quality and anticipated groundwater flowrate from the collection systems, it is envisioned that the aeration tank will have an approximate capacity of 150,000 gallons. The clarifier will have an approximate capacity of 100,000 gallons. Detailed engineering and design will have to be completed to properly design an effective and economical activated sludge system.

5-33a

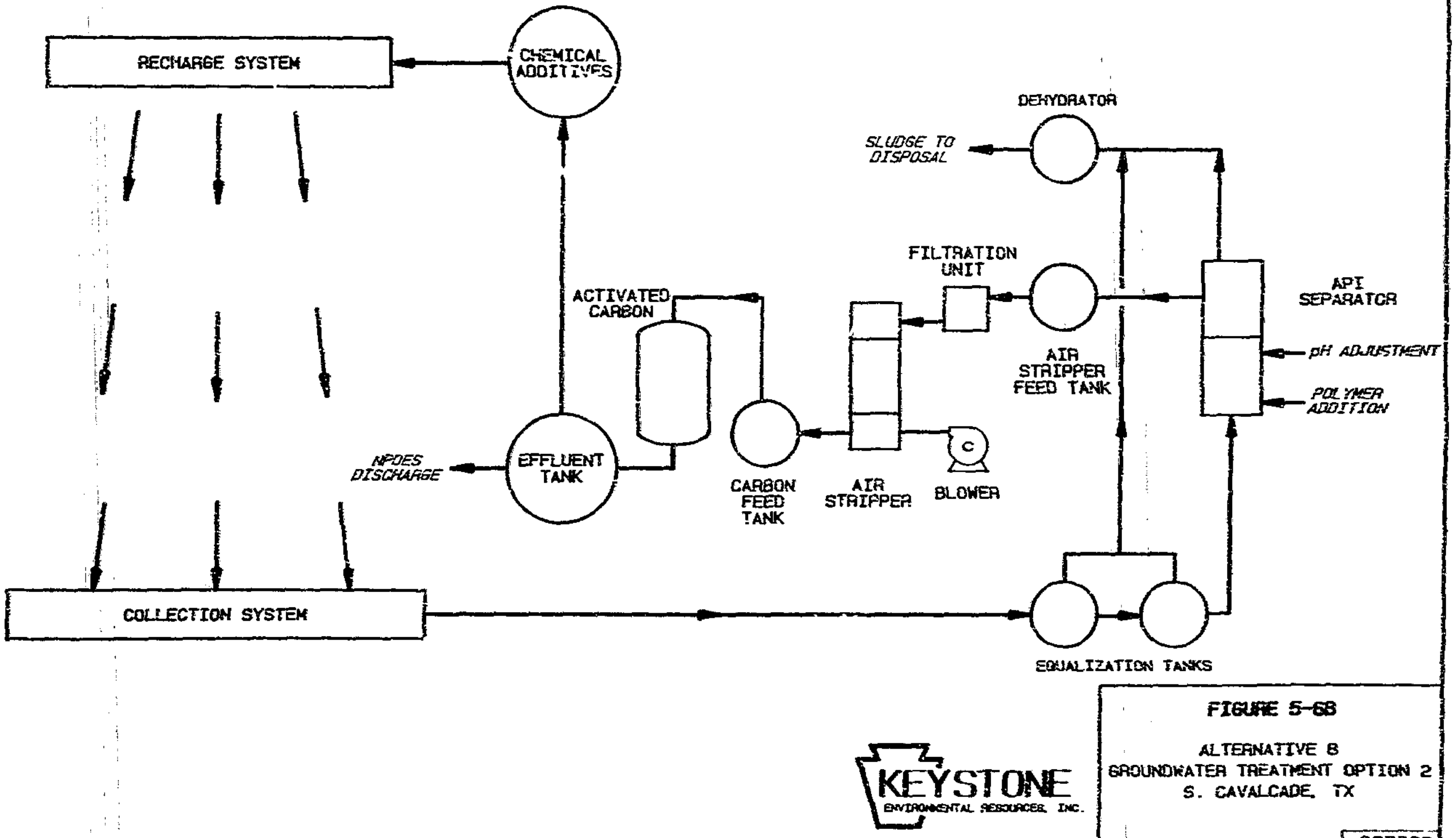

FIGURE 5-6B

ALTERNATIVE 6
GROUNDWATER TREATMENT OPTION 2
S. CAVALCADE, TX

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Discharge of the treated effluent will be as in the above groundwater re-injection and excess effluent discharge options under Alternative 3. Figure 5-6C presents a schematic flow diagram of this Alternative 8 (Groundwater treatment option 3 - physical/chemical separation followed by activated sludge biological treatment).

5.10.2 Compliance with ARARs

All chemical and location specific ARARs identified in Section 3.0 will be meet under this alternative and its associated three groundwater treatment options.

The action specific ARARs pertaining directly to the three groundwater treatment for discharge of waters under 40 CFR Part 429 are neither applicable nor relevant and appropriate for this operation because these requirements pertain solely to operation and not discharge after closure of a wood preserving site. Therefore, NPDES effluent limitations and monitoring requirements will be determined by a case specific evaluation as required by 40 CFR Part 125. In turn the groundwater treatment option will be designed to meet these limitations.

In addition, action specific ARARs from the Texas Air Regulations for air emissions pertaining to groundwater treatment option 2 involving air stripping of volatile compounds will have to meet.

5.10.3 Reduction of Toxicity, Mobility or Volume

This alternative would result in a significant, irreversible reduction of toxicity, mobility and volume of contaminants. Groundwater treatment options 1 & 2 would effectively adsorb the contaminants of concern (PCOC's) onto a fixed media for removal and subsequent disposal. Groundwater treatment option 3 would eventually convert the (PCOC's) to harmless products (primarily water and carbon dioxide). The end result incorporating any of the three groundwater treatment options would be the elimination of the PCOC's in the shallow groundwater system or reduction to the maximum extent possible.

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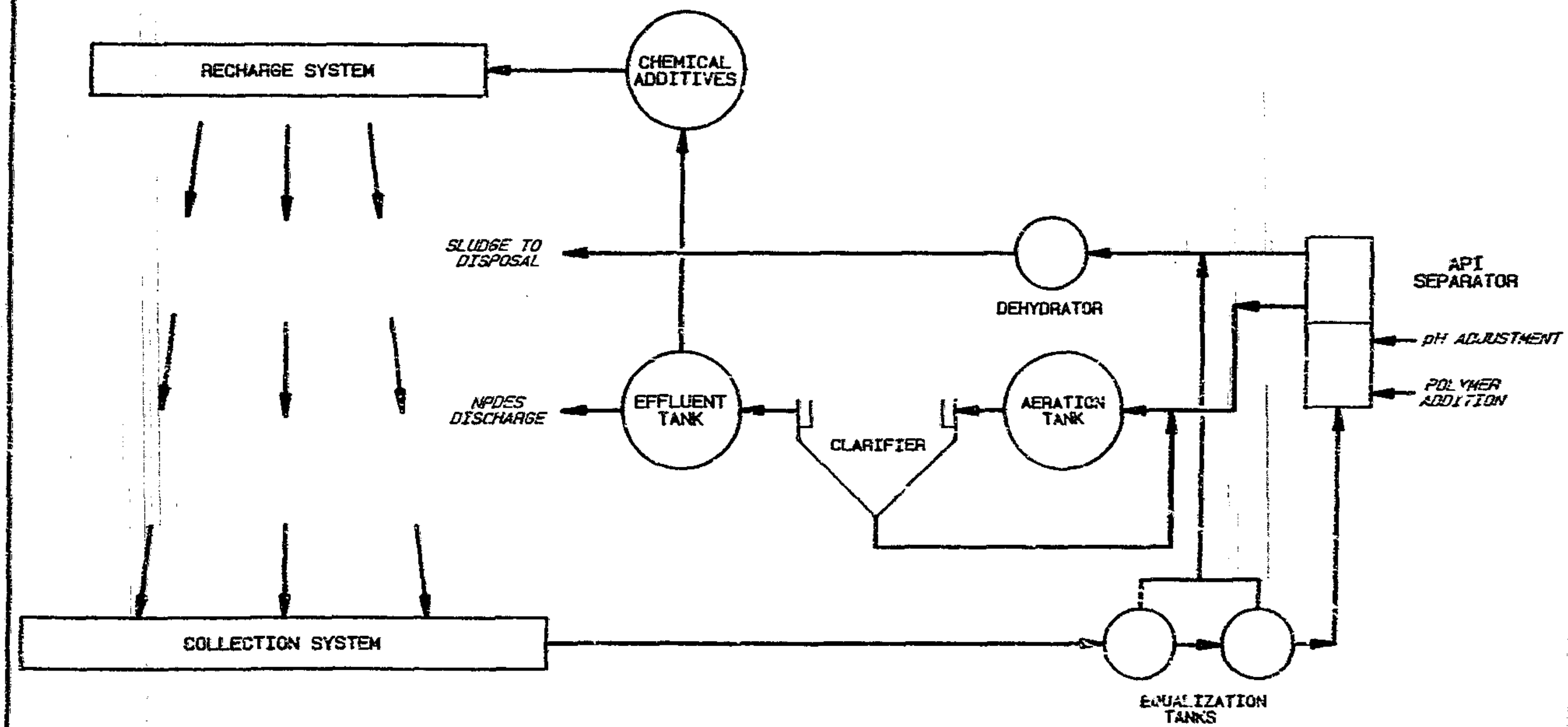

FIGURE 5-6C

ALTERNATIVE 8
GROUNDWATER TREATMENT OPTION 3
S. CAVALCADE, TX

KEYSTONE ENVIRONMENTAL RESOURCES, INC.

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5.10.4 Short-Term Effectiveness

Because the commercial areas of the site are concrete paved there exists a small chance for exposure to the public. However, there exists a potential for exposure to on-site commercial occupants during remediation. The bioreclamation process is a slow degradation process, this alternative would not meet site remediation goals quickly. This alternative would require several years to complete. In addition, potential worker exposures can be reduced if workers follow appropriate health and safety procedures.

5.10.5 Long-Term Effectiveness

Bioreclamation of the soils and groundwater in the northern and southern areas of the site would have long-term effectiveness. The site would no longer contain elevated levels of PCOCs, the levels would be reduced to the maximum extent practical. Exposure to residents and workers would be greatly reduced or eliminated.

5.10.6 Implementability

The construction of the facilities associated with the soil flushing alternative are essentially the same as for the bioreclamation alternative. Therefore, the construction should not be prohibited by site conditions. The operational reliability of the soil flushing alternative will be primarily assessed during predesign treatability studies. The groundwater collection and reinjection system is a reliable method for gathering and conveying the groundwater.

The disposal permits and approvals required to implement the soil flushing alternative are the same as for the bioreclamation alternative except for the addition NPDES permit requirement (see Section 5.4.6).

The three groundwater treatment options are different and should be assessed separately in term of implementability. In general, the facilities and equipment requirements for each option are easily obtained and present no difficulties in terms of implementation. The reliability and time requirements for each option are discussed below.

5.10.6.1 Groundwater Treatment Option 1

Engineering design, equipment procurement, construction, and startup of the groundwater treatment system would require approximately 8 to 12 months to complete. The treatment system proposed under this alternative has been widely applied for water treatment and therefore, special engineering or construction requirements are not anticipated. Relatively few pieces of equipment are required and are readily obtainable from commercial vendors thus allowing for the shortest implementation time as compared to the other two alternatives.

5.10.6.2 Groundwater Treatment Option 2

This alternative is the same as option 1 except that engineering design, equipment procurement, construction, and startup of the groundwater treatment system would require approximately 9 to 14 months to complete. Air stripping equipment can be purchased as a package unit or the system components can be purchased separately. In either case, the equipment is readily obtainable. Engineering evaluation and predesign work would need to be completed to determine the optimal stripper to be purchased. All other components in the wastewater treatment system are readily obtainable from commercial vendors.

5.10.6.3 Groundwater Treatment Option 3

Engineering design, equipment procurement, construction, and startup of the groundwater treatment system would require approximately 12 to 18 months to complete. The treatment system proposed under this alternative has been widely applied for water treatment and therefore, special engineering or construction requirements are not anticipated. The time limiting factor for this alternative is the construction of the large tanks (aeration tank and clarifier) which are expected to require approximately four months to complete. The other process equipment is readily available from commercial vendors or requires a short lead time for delivery.

The biological seed sludge used to startup the activated sludge unit could be readily obtained from an industrial treatment system processing similar organic constituents, or if needed, from a municipal sewage treatment system. Biological sludge obtained from a municipal system, however, would need to be acclimated to the site groundwater over a period of about two months to run at optimum efficiency. If it is determined through site-specific treatability testing that adequate organic carbon is not available to maintain viable activated sludge, an external carbon source will be provided.

Since the organic constituents present in the groundwater would be partially converted to biological solids, provisions would need to be included for management and disposal of this material. Provisions may be required for disposal of wasted activated sludge to a hazardous waste disposal facility.

Construction of the wells and associated piping will take about 4 months to complete. The water treatment plant can be constructed and operational in an additional 7 months. The concrete cap can be constructed concurrently with the other activities. The total time for remediation of the entire site cannot be determined; however an estimate of 30 years was used for all costing purposes.

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5.10.7 Cost

The total present worth costs for the soil flushing alternative and three groundwater treatment options is as follows:

5.10.7.1 Groundwater Treatment Option 1

Table 5-9a presents a summary of the present worth costs for this groundwater treatment option. As can be seen from the table the present worth costs for this option is $8,300,000. Present worth costing was based upon an initial capital investment of $3,805,000 and annual operating costs of $482,220 invested at a 10% interest rate for a 30 year period. Appendix C Tables C-15 and C-16 contain the detailed capital and annual operating cost breakdown for Alternative 8: Groundwater Treatment Option 1.

5.10.7.2 Groundwater Treatment Option 2

Table 5-9b presents the present worth of this groundwater treatment option as $8,500,000. This includes the initial capital investment of $4,026,400 and annual

TABLE 5-9A

PRESENT WORTH COST SUMMARY FOR

ALTERNATIVE 8

GROUNDWATER TREATMENT OPTION 1

PHYSICAL/CHEMICAL SEPARATION FOLLOWED BY GRANULAR MEDIA FILTRATION AND ACTIVATED CARBON TREATMENT

Capital Cost		Cost ($)
1.	Collection and Recharge Systems	2,221,100
2.	On Site Groundwater Treatment System Direct Costs	708,500
3.	On Site Groundwater Treatment System Indirect Costs	93,000
4.	Health and Safety Requirements During Construction	16,000
5.	State and Local Fees	5,000
	Capital Costs	3,043,600
	Contingency allowances (25% of Capital Costs)	761,000
Total Capital Costs		3,805,000

Operation and Maintenance Costs		Costs ($/year)
1.	Chemicals	201,000
2.	Electrical Requirements	7,860
3.	Sludge Disposal	33,750
4.	Man Power	151,840
5.	Sampling and Analyses	71,750
6.	Maintenance (2% of Groundwater Treatment System Direct and Indirect Costs)	16,000
Total O & M Costs		482,222
Present Worth ($) @ (10%-30 years)		8,300,000

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TABLE 5-9B

PRESENT WORTH COST SUMMARY FOR

ALTERNATIVE 8

GROUNDWATER TREATMENT OPTION 2

PHYSICAL/CHEMICAL SEPARATION FOLLOWED BY GRANULAR MEDIA FILTRATION WITH AIR STRIPPING AND ACTIVATED CARBON TREATMENT

Capital Cost	Cost ($)
1. Collection and Recharge Systems	2,221,100
2. On Site Groundwater Treatment System Direct Costs	872,000
3. On Site Groundwater Treatment System Indirect Costs	107,000
4. Health and Safety Requirements During Construction	16,000
6. State and Local Fees	5,000
Capital Costs	3,221,100
Contingency allowances (25% of Capital Costs)	805,300
Total Capital Costs	4,026,400

Operation and Maintenance Costs	Costs ($/year)
1. Chemicals	194,000
2. Electrical Requirements	9,600
3. Sludge Disposal	33,750
4. Man Power	151,840
5. Sampling and Analyses	71,750
6. Maintenance (2% of Groundwater Treatment System Direct and Indirect Costs)	19,000
Total O & M Costs	479,960
Present Worth ($) @ (10%-30 years)	8,500,000

operating costs of $479,960 invested at 10% interest rate for 30 years. Detailed analysis for this costs summary is presented in Appendix C in Tables C-17 and C-18.

5.10.7.3 Groundwater Treatment Option 3

The present worth for Alternative 3 with groundwater treatment Option 8 is $8,700,000. This includes an initial capital investment of $4,490,100 and an annual operating costs of $454,110 invested at a 10% interest rate for a 30 year period. Refer to Table 5-9c for a presentation of this cost breakdown. Details for the above costs are included in Appendix C in Tables C-19 and C-20.

The above cost estimates for the groundwater treatment systems are based on Keystone's experience in wastewater treatment and engineering judgement. Soil excavation, capping and related construction activities were referenced in the Mean's Facilities Cost Data and guidance provided by the EPA "Remedial Action at Waste Disposal Sites" document. A 25% contingency has been applied to the costs due to the conceptual nature of the system design elements.

5.10.8 Overall Protection of Human Health and the Environment

This alternative will greatly reduce the concentrations of PCOCs in the groundwater, thereby reducing the possibility of long term exposure and future site remediation. This alternative will pose minimal potential health and environmental effects to residents and the environment in the vicinity of the site.

TABLE 5-9C

PRESENT WORTH COSTS SUMMARY FOR

ALTERNATIVE 8

GROUNDWATER TREATMENT OPTION 3

PHYSICAL/CHEMICAL SEPARATION FOLLOWED BY ACTIVATED SLUDGE BIOLOGICAL TREATMENT

Capital Cost	Cost ($)
1. Collection and Recharge Systems	2,221,100
2. On Site Groundwater Treatment System Direct Costs	1,212,000
3. On Site Groundwater Treatment System Indirect Costs	138,000
5. Health and Safety Requirements During Construction	16,000
6. Sate and Local Fees	5,000
Capital Costs	3,592,100
Contingency allowances (25% of Capital Costs)	898,000
Total Capital Costs	4,490,100

Operation and Maintenance Costs	Costs ($/year)
1. Chemicals	151,000
2. Electrical Requirements	12,000
3. Sludge Disposal	40,500
4. Man Power	151,840
5. Sampling and Analyses	71,750
6. Maintenance (2% of Groundwater Treatment System Direct and Indirect Costs)	27,000
Total O & M Costs	454,110

Present Worth ($) @ (10%-30 years)	8,700,000

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6.0 SUMMARY OF REMEDIAL ACTION ALTERNATIVES

This section of the Feasibility Study summarizes the detailed evaluation conducted in section 5 on the remedial action alternatives. Each alternative was evaluated based upon compliance with ARAR's, reduction in toxicity, mobility or volume, short-term effectiveness, long-term effectiveness, implementability, cost and overall protection of human health and the environment. Table 6-1 presents a summary of this detailed evaluation for the soils and groundwater alternatives. In addition to the table, a brief discussion characterizing the advantages and disadvantages of each alternative follows.

6.1 Soil And Groundwater Alternative

6.1.1 No Action (Monitoring/Limited Access/ Deed Restrictions)

Under the no action alternative, which pertains to both the soil and groundwater media, no remedial action will take place. A long-term soil and groundwater monitoring program will be implemented in addition to institutional controls utilizing deed notices to help reduce the potential that site contaminants will be disturbed by property owners.

The primary advantages of the no action alternative are:

* It has the lowest present worth of all alternatives.

* It eliminates any short term risks associated with site remediation (excavation potential exposure to volatiles and/or PAH compounds).

The primary disadvantages of the no action alternative are:

* The shallow groundwater aquifer may potentially function as a source of PCOC contamination to the lower 220 and 550 foot aquifiers.

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TABLE 6-1

SUMMARY OF DETAILED EVALUATION OF REMEDIAL ACTION ALTERNATIVES

REMEDIAL ALTERNATIVE	COMPLIANCE WITH ARARS	REDUCTION IN TOXICITY, MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	LONG-TERM EFFECTIVENESS	IMPLEMENTABILITY	PRESENT WORTH COST (1000s)	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
SOIL AND GROUNDWATER ALTERNATIVE							
Alternative 1: No Action							
	ARARs not met	Does not reduce or remove PCOCs	No increased potential risk to on-site workers	Long-term aquifer monitoring necessary PCOCs may migrate to lower aquifer	Easily monitored long-term monitoring and sign maintenance needed	$384	No reduction of potential exposure or migration pathways of PCOCs
SOIL ALTERNATIVES							
Alternative 2: In Situ Stabilization Followed by Capping							
	All ARARS met	Mobility of PCOCs is reduced No reduction in toxicity and volume	Potential for direct contact with PCOCs eliminated after cap in place Potential for worker exposure during clean up	Alternative is not permanent solution Exposure and migration reduced as long as site maintained	Easily implemented Laboratory and field studies required for fixing agent	$14,800	Human health and environment protected due to reduction in potential migration and exposure Possible future site remediation required if alternative fails

TABLE 6-1 (continued)

SUMMARY OF DETAILED EVALUATION OF REMEDIAL ACTION ALTERNATIVES

REMEDIAL ALTERNATIVE	COMPLIANCE WITH ARARS	REDUCTION IN TOXICITY, MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	LONG-TERM EFFECTIVENESS	IMPLEMENTABILITY	PRESENT WORTH COST (1000s)	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
Alternative 4: Excavation with On-Site Soil Treatment							
On-Site Treatment Option: Soil Washing							
	All ARARs met	Toxicity, mobility and volume of PCOCs reduced Leaching of PCOCs may be problem	Quick removal of public exposure pathways Potential for worker exposure during excavation Potential for emissions during excavation	Potential for low-level leaching from treated soils	Potential access problems at site Standard excavating equipment required Dome may be required over excavation	$7,000	Human health and environment protected due to reduction of potential migration and exposure pathways
On-Site Treatment Option: Incineration							
	All ARARs met	Permanent reduction of toxicity, mobility and volume of PCOCs Metals will not be reduced	Quick reduction of PCOCs Potential for worker exposure during excavation	Permanent method of remediation	Confirmation testing and ash testing will be necessary and may delay implementation Potential access problems at site Standard excavating equipment required	$10,400	Human health and environment protected due to elimination of potential migration and exposure pathways

6-17

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TABLE 6-1 (continued)

SUMMARY OF DETAILED EVALUATION OF REMEDIAL ACTION ALTERNATIVES

REMEDIAL ALTERNATIVE	COMPLIANCE WITH ARARS	REDUCTION IN TOXICITY, MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	LONG-TERM EFFECTIVENESS	IMPLEMENTABILITY	PRESENT WORTH COST (1000s)	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
Alternative 5: In Situ Treatment							
Alternative: Bioreclamation							
	All ARARs met	Permanent reduction of toxicity, mobility and volume of PCOCs Some mobility of PCOCs could occur for material left after treatment	Potential for worker exposure during excavation Remediation of soils may be long.	Permanent method of remediation Groundwater PCOCs may be pushed off-site at Palletized Trucking Company	Relatively easy to implement Pilot or laboratory scale testing may be required before implementation	$530	Human health and environment protected due to elimination of potential exposure and migration pathways
Alternative: Soil Flushing							
	All ARARs met	Permanent reduction of toxicity, mobility and volume of PCOCs Some mobility of PCOCs could occur for material left after treatment	Potential for worker exposure during excavation Remediation of soils may be long.	Permanent method of remediation Groundwater PCOCs may be pushed off-site at Palletized Trucking Company	Relatively easy to implement Pilot or laboratory scale testing may be required before implementation	$530	Human health and environment protected due to elimination of potential exposure and migration pathways

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TABLE 6-1 (continued)

SUMMARY OF DETAILED EVALUATION OF REMEDIAL ACTION ALTERNATIVES

REMEDIAL ALTERNATIVE	COMPLIANCE WITH ARARS	REDUCTION IN TOXICITY,MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	LONG-TERM EFFECTIVENESS	IMPLEMENTABILITY	PRESENT WORTH COST (1000s)	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
Alternative 6: Excavation and Off-Site Incineration Treatment							
	All ARARs met	Permanent reduction of toxicity, mobility and volume of PCOCs	May take up to six years to reduce concentration of PCOCs Potential for worker exposure during excavation	Permanent method of remediation	Potential access problems at site Confirmation testing and ash testing will be necessary and may delay implementation Dome may be required to cover excavation	$62,000	Human health and environment protected due to elimination of potential migration exposure pathways
GROUNDWATER ALTERNATIVES							
Alternative 7: Groundwater Collection And In Situ Treatment (Bioreclamation) with Physical/Chemical Separation Followed by Disposal							
	Any new more stringent city permit restrictions may not be met	Significant reduction of toxicity, mobility and volume of PCOCs and metals Some potential for migration exists	Small potential for worker exposure to PCOCs	Permanent method of remediation	Materials and equipment readily available Acceptance of treated water by POTW may delay remediation Installation may be difficult	$6,500	Human health protected due to significant reduction in concentrations of PCOCs

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TABLE 6-1 (continued)

SUMMARY OF DETAILED EVALUATION OF REMEDIAL ACTION ALTERNATIVES

REMEDIAL ALTERNATIVE	COMPLIANCE WITH ARARS	REDUCTION IN TOXICITY, MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	LONG-TERM EFFECTIVENESS	IMPLEMENTABILITY	PRESENT WORTH COST (1000s)	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
Alternative 8: Groundwater Collection and In Situ Treatment (Soil Flushing) with On-Site Groundwater Treatment Followed by Disposal							
Groundwater Treatment Option 1: Physical/Chemical Separation Followed by Granular Media Filtration and Activated Carbon Treatment							
	All ARARs met	Significant, irreversible reduction of toxicity, mobility and volume of PCOCs	Small potential for public and worker exposure to PCOCs	Levels of PCOCs will be reduced to maximum extent possible	Materials and equipment readily available Implementation period is 8 to 12 months Need NPDES Permit	$8,300	Human health and environment protected due to significant reduction in concentrations of PCOCs
Groundwater Treatment Option 2: Physical/Chemical Separation Followed by Granular Media Filtration with Air Stripping and Activated Carbon Treatment							
	All ARARs met	Significant, irreversible reduction of toxicity, mobility and volume of PCOCs	Small potential for public and worker exposure to PCOCs	Levels of PCOCs will be reduced to maximum extent possible	Materials and equipment readily available Implementation period is 9 to 14 months Need NPDES Permit	$8,500	Human health and environment protected due to significant reduction in concentrations of PCOCs

TABLE 6-1 (continued)

SUMMARY OF DETAILED EVALUATION OF REMEDIAL ACTION ALTERNATIVES

REMEDIAL ALTERNATIVE	COMPLIANCE WITH ARARS	REDUCTION IN TOXICITY, MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	LONG-TERM EFFECTIVENESS	IMPLEMENTABILITY	PRESENT WORTH COST (1000s)	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
Alternative 3: Excavation with Disposal at Off-Site Landfill							
	New land disposal restrictions may not be met	Complete reduction in mobility, toxicity and volume at site Toxicity and volume will not be reduced at landfill	Site remediation goals met quickly Potential for worker exposure during excavation Potential for emissions during excavation	Permanent method of remediation for site, but not for final disposal site.	Potential access problems at site Standard excavating equipment required Dome may be required over excavation	$10,000	Human health and environment protected due to elimination of potential migration and exposure pathways Potential exposure to residents in vicinity of landfill

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TABLE 6-1 (continued)

SUMMARY OF DETAILED EVALUATION OF REMEDIAL ACTION ALTERNATIVES

REMEDIAL ALTERNATIVE	COMPLIANCE WITH ARARS	REDUCTION IN TOXICITY, MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	LONG-TERM EFFECTIVENESS	IMPLEMENTABILITY	PRESENT WORTH COST (1000s)	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
Groundwater Treatment Option 3: Physical/Chemical Separation Followed by Activated Sludge Biological Treatment							
	All ARARs met	Significant, irreversible reduction of toxicity, mobility and volume of PCOCs	Small potential for public and worker exposure to PCOCs	Levels of PCOCs will be reduced to maximum extent possible	Materials and equipment readily available Implementation period is 12 to 18 months Provision will be necessary for disposal of biological solids Need NPDES Permit	$8,700	Human health and environment protected due to significant reduction in concentrations of PCOCs

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* The PCOCs for the site are not treated or destroyed, therefore no reduction of toxicity, mobility or volume will occur.

6.2 Soil Alternatives

6.2.1 In Situ Stabilization Followed By Capping

The areas of the site where surficial and surface soil contamination has been identified will be chemically stabilized to reduce leaching and covered with a protective barrier of concrete.

The principal advantages of this alternative are:

* The mobility of the contaminants should be reduced.

* The concrete cover eliminates the potential for direct contact with PCOCs in the soils.

The principal disadvantages are:

* PCOCs are only immobilized and not destroyed therefore potential risk may result in the future.

* Bench scale and/or laboratory tests will be required to demonstrate the effectiveness of chemically fixing the site soils.

* There is no guarantee that the chemical fixation process will endure a 30 year period.

* If the process fails future site remediation will be required.

6.2.2 Excavation With Disposal At Off-Site Landfill

Under this alternative the contaminated surficial and surface soil areas that require remediation will be excavated to a depth of six feet and transported to an approved off-site landfill.

The primary advantages of this alternative are:

* Would significantly reduce the mobility of the PCOCs completely and permanently in the surficial and surface soils.

* It provides for both short-term and long-term effectiveness at the site.

The primary disadvantages are:

* Near-future CERCLA disposal regulations may make this alternative inappropriate.

* There is still a liability associated with the disposed soils since they are not treated.

* Potential exposure risks can occur during the excavation activities.

* Excavation activities at the site will be difficult because of access problems.

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6.2.3 Excavation With On-Site Treatment

6.2.3.1 Soil Washing

Under this treatment option for Alternative 4, the contaminated surficial and surface soil areas will be excavated to a depth of six feet and treated on-site in a soil washing process.

Advantages associated with this treatment option for Alternative 4 are:

* It provides for removal and treatment of PCOCs from the surficial and surface soils.

* Provides for reduction of toxicity and volume through treatment of wash waters.

* Provides for short-term effectiveness.

* Treatability testing indicates soils can be effectively cleaned with the proper surfactants.

Disadvantages are:

* Does not meet long-term effectiveness.

* Potential exposure risks can occur during excavation.

* Potential exists for low level leaching of treated soils.

* May require pilot study prior to implementation.

6.2.3.2 Incineration

The on-site incineration treatment option for Alternative 4, requires that the identified contaminated surficial and surface soils be excavated to a depth of six feet and transported on-site to a rental incineration unit.

The advantages to this treatment option are:

* It provides for complete removal and treatment of PCOCs in the surficial and surface soils.

* It provides for both short-term and long-term effectiveness.

* It is a proven technology.

Disadvantages are:

* Will not treat metals in the soils.

* Potential exposure risks can occur during excavation.

* Trial burn may be necessary to confirm effectiveness on site soils, time delay possible.

6.2.4 In Situ Treatment

6.2.4.1 Bioreclamation

Under this in situ treatment option the surficial and surface soils will be treated in place via a biodegradation process. This is accomplished by enhancing the surface soils with fertilizers, lime , water and oxygen to a depth of approximately one foot. In addition shallow zone groundwaters with nutrients added will be sprayed onto the surface soils to promote biodegradation. Soil monitoring will be implemented in order to determine that the soils have been treated to the level necessary for the attainment of site clean-up goals.

The major advantages of this in situ treatment option are:

* Involves treatment of the soils and would permanently reduce toxicity, mobility and volume of PCOC contaminated soils.

* Meets both short-term and long-term effectiveness.

* Minimal excavated is required for perforated piping system.

* Treatability tests indicate that in situ biodegradation can be an effective treatment technology.

* Lowest present worth of all soil alternatives.

Disadvantages are:

* Treatment may be necessary for several years in order to reach clean-up goals.

* Limited access at the Palletized Trucking Company may result in lack of space for a collection system, therefore, contaminant may be pushed off-site.

* Because this is a new and innovative technology a pilot study will be required to determine its ultimate suitability.

6.2.4.2 Soil Flushing

Contaminated surficial and surface soils will be treated in situ by soil flushing with a water solution containing surfactants which will dissolve the contaminates into the groundwater where they will then be extracted and treated. 007892

Advantages are:

* Involves treatment of the soils and would permanently reduce toxicity, mobility and volume of PCOC contaminated soils.

* Would meet short-term and long-term effectiveness.

* Present worth cost estimate, as with the bioreclamation in situ treatment option, are the lowest of all soil alternatives.

Disadvantages are:

* Treatment may be necessary for several years in order to achieve clean-up goals.

* Pilot and bench scale tests may be necessary to determine ultimate suitability.

* Limited access at the Palletized Trucking Company may result in lack of space for a collection system, therefore, contaminants may be pushed off-site.

6.2.5 Excavation and Off-Site Incineration

Under this soil alternative the contaminated surface and surficial soils will be excavated to a depth of six feet and transported to a nearby approved off-site incinerator.

Advantages associated with this alternative are:

* This alternative would provide for the permanent reduction in toxicity, mobility and volume of organics in the surface and surficial soils.

* Would meet both short-term and long-term effectiveness.

* It is a proven technology.

* A incinerator is located within the immediate vicinity.

Disadvantages are:

* Its present worth is the highest of all alternatives.

* Potential exposure exists during the excavation process.

* Access is limited by the Palletized Trucking Company, possible implementation delays.

* Confirmation testing (trial burn) may be necessary, possible delays.

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6.3 Groundwater Alternatives

6.3.1 Groundwater Collection and In Situ Treatment (Bioreclamation) with Physical/Chemical Separation followed by Disposal

Under this alternative the affected groundwater within the shallow zone aquifer will be recovered via a series of pumping wells. The recovered groundwater will be treated above ground with physical/chemical separation. The treated groundwater will be partially reinjected back into the aquifer through a series of reinjection wells after being enhanced with nutrients or surfactants . The remaining volume of groundwater will be discharged off-site to the City of Houston POTW.

The advantages to this alternative are:

* Provides for near or complete removal of all non-aqueous phase liquids (NAPL's).

* It provides for long-term and short-term effectiveness.

* Would provide a significant reduction of toxicity, mobility, and volume for both organic contaminants and metals.

* Has the lowest present worth of all groundwater alternatives.

Disadvantages are:

* Installation of pumping and reinjection well systems can be difficult because of access problems by Palletized Trucking Company.

* Treatment may be necessary for many years to achieve clean-up goals.

* This alternative will require approval from the City of Houston POTW for acceptance of discharge, this could prolong implementation.

6.3.2 Groundwater Collection and In Situ Treatment (Soil Flushing) with On-Site Groundwater Treatment followed by Disposal

Groundwater will be recovered via a series of pumping wells and then treated on site by one of the three following groundwater treatment systems:

6.3.2.1 Groundwater Treatment Option 1 Physical/Chemical Separation followed by Granular Media Filtration and Activated Carbon Treatment

Refer to Figure 5-6A for a schematic representation of this treatment option.

Advantages are:

* Would result in a irreversible reduction of toxicity, mobility and volume on contaminates.
* Proven technology and is effective in treating site related organic contaminants based on treatability tests.
* Relatively few major components in this wastewater treatment system, therefore shortest time for implementation.
* Lowest present worth of the three groundwater treatment options considered under this alternative.

Major Disadvantages are:

* Treatment may be necessary for many years to obtain site clean-up goals.

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* Access is limited for the implementation of the pumping and reinjection wells.

* Attainment of an NPDES permit may prolong implementation.

6.3.2.2 Groundwater Treatment Option 2 Physical/Chemical Separation followed by Granular Media Filtration with Air Stripping and Activated Carbon Treatment

Refer to Figure 5-6B for details on this treatment option.

Advantages associated with this option are:

* Would result in irreversible reduction of toxicity,mobility and volume of contaminants.

* Proven technology. In addition, treatability report indicates that volatiles are present and air stripping is recommended to significantly reduce carbon usage.

Disadvantages are:

* Treatment may be necessary for many years to attain site clean-up goals.

* Access is limited for the implementation of the pumping and reinjection wells.

* Must attain an NPDES permit for discharge, this could prolong implementation.

* It may be necessary to treat the vapors from the air stripping unit to comply with the State of Texas air regulations.

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6.3.2.3 Groundwater Treatment Option 3 Physical/Chemical Separation followed by Activated Sludge Biological Treatment

Figure 5-6 presents a schematic representation showing the major pieces of equipment associated with its treatment option.

Advantages are:

* Would result in irreversible reduction of toxicity, mobility and volume of contaminants.

* Proven technology as indicated in Treatability Report (section 4.8 Activated Sludge Co-Treatability Data.

Disadvantages are:

* Treatment may require many years to attain site clean-up goals.

* Access for pumping and reinjection wells is limited, may prolong implementation.

* Must obtain an NPDES permit, this will require time for implementation.

* This treatment system will take the longest time to implement

* Highest present worth of all groundwater treatment systems.

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